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MAINTENANCE AND REPAIR ORGANIZATION IN INDUSTRIAL ENTERPRISES

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MAINTENANCE & REPAIR ORGANISATION IN INDUSTRIAL ENTERPRISES

INTRODUCTION

The purpose of this paper is to outline the basic requirements of maintenance and repair organisations. The actual requirements to suit any situation, whether in developed or underdeveloped countries, will vary with the type and size of industry, the local surroundings, the normal weather conditions, the degree of local industrialisation, labour availability and many other factors. However, these requirements can be established in relation to the basic features outlined.

Before any effective maintenance and repair organisation can be established, there must be a recognition at top management level of the vital need for such an organisation, and an understanding of its aims and objectives.

It should be recognised that such an organisation is an integral part of the process of production. The costs of a maintenance and repair organisation must be seen as an operating cost which can have a significant effect on the ultimate product cost.

It is a gross mistake to aim to reduce maintenance and repair costs without reference to the effect on other factors such as plant availability and production rate.

Reduction of maintenance and repair costs by reduction of maintenance and repair activity, will result in reduction of plant availability. Equally reduction of expenditure on equipment replacement will result in reduction of production rate or efficiency by continuation of use of worn out or patched up machinery.

Understanding of the impact of such factors on overall production costs is necessary at top management level and all levels in production and

2. TERMINOLOGY

Terminology in current use to describe maintenance and repair activities varies from place to place.

In order to avoid misunderstandings with regard to the ideas presented in this paper, the meanings ascribed to terms used are listed in Appendix I.

3. STRUCTURE OF MAINTENANCE AND REPAIR ORGANISATIONS

Before we can consider the structure of the organisation needed to undertake maintenance and repair of an industrial enterprise, we must first examine the enterprise.
Dependant on the circumstances of the enterprise, it is often convenient to include various functions within the responsibilities of the maintenance and repair organisation.

Such a situation is an acceptable one providing the separate functions are recognised and the strength of the organisation is determined accordingly. Non-recognition of the various functions and responsibilities can lead to neglect of one or other of them, to the overall detriment of the enterprise.

3.1. The primary functions of any maintenance and repair organisation will include the following:-

3.1.1. Provision of adequate and suitable manpower and facilities to maintain production plant at the desired level of operational availability, efficiency and appearance.

3.1.2. Provision of manpower and facilities to maintain service plant, buildings, and roadways at the desired level of availability, efficiency and appearance.

3.1.3. Provision of facilities for the progressive self improvement of the performance of the organisation in terms either of production plant availability or production cost or both.

3.2. Secondary activities which may be included in the responsibilities of a maintenance organisation as circumstances dictate could include:-

3.2.1. Provision of facilities for the progressive development of the production facilities in terms of either improved throughput, improved economics, modernisation or expension.

3.2.2. Provision of the factory services. This could involve operation of power generation facilities, steam raising plant, water supply and treatment facilities and effluent treatment and disposal facilities.

3.2.3. Provision of facilities for procurement and storage of items of equipment either for maintenance and repair use or for general use.

3.2.4. Provision and operation of transport facilities either for internal factory use or even for transport of raw materials and finished products outside the factory.

3.2.2. The functions listed 3.2.1. to 3.2.4. inclusive are possible extra responsibilities for a maintenance and repair organisation, as the background and training of the personnel of the organisation often make it the most capable group to deal with them.

Generally, these sort of additional responsibilities are added in smaller enterprises where setting up of separate organisations to handle them cannot be justified.

It is desirable, whenever possible, to separate such functions entirely from the maintenance and repair organisation. When it is not economically justifiable to set them apart in a separate organisation, it is necessary to separate them within the maintenance and repair organisation. This separation must be made in terms of the personal responsibilities of members of the managerial or supervisory staff. If this is not done there is a real danger that either one function or the other will suffer neglect.

with larger enterprises where such additional functions achieve sizable proportions, the temptation to incorporate them must be avoided. Equally, as enterprises grow, it is necessary to re-assess the needs and separate out such additional functions as soon as possible.

3.3. Having clarified the true functions of the maintenance and repair organisation, we can now look at the separate responsibilities which go into meeting the three primary functions.

The work of the organisation will include the ability to undertake:-

3.3.1. Emergency maintenance and repair work.

3.3.2. Planned maintenance and repair work - this will probably include a mixture of breakdown, shutdown, scheduled and preventative maintenance work.

3.3.3. Operation of engineering workshop facilities.

3.3.4. Provision of diagnostic service to determine causes of malfunction of production or service equipment.

3.3.5. Operation of a planning service to provide for control of the overall use of manpower and facilities.

3.3.6. Operation of a plant inspection and records system.

3.3.7. Establishment and review of levels of spare parts stock.

3.3.8. Installation of minor plant modifications and extensions.

3.3.9. Provision of technical service to improve performance or working life of plant or reduce the maintenance costs.

3.4. Let us now examine each of these aspects of the responsibilities.

Emergency maintenance and repair work can vary between minor jobs requiring no more than one or two manhours of effort and major work involving the sustained effort of a large section of the workforce.

Similarly planned work may vary greatly in the amount of effort necessary to complete it.

when considering the structure of the organisation necessary to handle the different calls for maintenance work, it is usually of more value to separate work in terms of the manhour requirements and priority.

This distinction can lead to a separation of the workforce into two or more teams or groups with different primary responsibilities.

Other separate responsibilities can also be established either grouped in terms of specific plant needs or work function. These would include such groups as say, machine shop, welders shop, sheet metal workshop, joiners or carpenters, vehicle maintenance etc.

Again dependant on the size of an organisation, it may be decided to carry out all these operations by separate teams. Alternatively all or groups of these operations may be carried out by one team having the necessary skills and training for the jobs to be covered.

3.4. The decisions on how to group such teams should be influenced by the following factors:-

3.4.1. The convenience of separating production facilities into areas grouped geographically or in terms of similar maintenance and repair requirements.

3.4.2. The base level of work requirements in each area.

3.4.3. The requirement for specialist services of any sort in one or all areas.

3.5. <u>Area Maintenance teams</u>

Generally it will be found possible to identify groups of production facilities which can provide a steady workload for a number of men. This work would consist of small emergency jobs and routine scheduled maintenance work such as oiling, greasing, and machine adjustments. Such jobs would not normally require much in the way of special equipment

or specialist work.

It is often convenient to establish small teams operating in such localised areas. Each team may have its own supervision or share a supervisor with a number of other teams.

3.5.1. Advantages to be gained from area teams include:-

3.5.1.1. The team develops an intimate knowledge of the plant in their area

3.5.1.2. They are readily available to deal with minor emergencies which, if given prompt attention, can avoid major plant downtime

3.5.1.3. They have direct responsibility for scheduled maintenance work in their own area. Without this area separation, one section of the plant may claim excessive attention due to perhaps the agressiveness of the production supervision in that section, or a more agreeable working environment.

3.5.2. The area team arrangement has a number of potential disadvantages which can be avoided with careful control. They are:-

3.5.2.1. Unless sized correctly to suit the base workload, they can overmaintain plant and become an expensive way to do maintenance. A continuous cross checking of the work they tackle and their manpower is necessary.

3.5.2.2. Such teams tend to accept present practices as essential for evermore. Often they will not challenge the need for a job which is part of their routine. Situation which may be major maintenance cost items may not be identified because dealing with them has become a routine job.

3.5.2.3. Seldom, when there is a reduction of workload in an area, whether short or long term, will it become apparent to management. The potential to use underemployed labour elsewhere will then be lost.

3.5.3. The main disadvantages can usually be avoided by undermanning such groups to the point where they regularly need to request additional assistance. This will tend to focus attention on their operation from a higher level on a regular basis.

Some sort of routine feedback of information on how their time is spent can also prove of use in identifying high cost operations.

It is advisable to resist the temptation to place such teams under the control of the production supervision in the area. This supervision will stubbornly resist any attempt to reduce the size of the team. In addition, the necessary control of engineering standard of work performed will be lost, with possible catastrophic results.

3.6. Centralised Maintenance Teams

With small enterprises, the question of whether to organise into area or centralised teams seldom arises. In these circumstances usually a single centralised team best suits the situation.

3.6.1. The decision to operate with a centralised team in a larger enterprise will be influenced by the following factors:-

3.6.1.1. Whether workload requirements for specialist skills are concentrated in a section of the production facilities or spread generally over the whole factory.

3.6.1.2. Whether there is a need for high capital investment for fixed facilities for any particular maintenance or repair operation. For example, the need for machine tools and workshop space, heavy fixed welding or pipe fabrication facilities or similar facilities.

3.6.1.3. Whether the general workload is steady in all sections of the factory or fluctuates from section to section.

3.6.2. In almost every case it will be found that there is need to concentrate the machine tool facilities and some if not all of the welding, sheetmetal working and woodworking facilities in centralised workshop.

In general also, with the larger enterprises, centralisation of part of the mechanical, electrical and instrument trades is desirable. These groups can be used as a workforce which can range over the factory, carrying out the bigger jobs where they occur.

It is unusual to find a situation in the larger enterprises where complete centralisation of the workforce is a practical proposition. A combination of the Area and Centralised will usually be found to be the most workable arrangements.

3.6.3. As with area teams, centralisation of the maintenance teams has its advantages and disadvantages.

Advantages include:-

3.6.3.1. The ability to ensure an even loading of the workforce

3.6.3.2. The centralised workforce lends itself more readily to work planning

3.6.3.3. It avoids the necessity of uprooting men from one area to tackle a heavy workload in another, as is necessary with a completely area organised force.

3.6.3.4. It permits men to gain wider experience over the whole of the factory giving the workforce greater flexibility.

3.6.3.5. Supervision is more readily arranged to cover major work, with regular teams used to one another and their supervisor.

3.6.4. The drawbacks largely centre around the wider field than the centralised groups cover. Principally they are the opposites to the advantages of area teams.

That is:-

3.6.4.1. The groups lack the intimate knowledge of the plant. Also they lack an attachment to any particular section of the plant around which to build a team spirit.

3.6.4.2. If work quality is not strictly controlled there is a danger of lack of care and attention to detail. The area man generally is aware that poor performance by him will result in a return to the same job. Lack of attention by the centralised man generally means trouble.

3.7. Combined Area and Centralised Maintenance Teams

Other than with small enterprises, it is most likely that a combination of both area and centralised maintenance teams is preferable. Determination of the optimum manpower split between a combination area and centralised organisation is a difficult problem.

It will depend on the incidence of emergency work together with the steady load of routine scheduled maintenance.

The scheduled workload is readily determined. The incidence of emergency work is quite another matter. Without some control system, all maintenance and repair work will be emergency work. It is only when manpower becomes difficult to obtain that production men start to order their priorities for service from the maintenance and repair organisation. By steadily reducing the strength of area teams and requiring production people to be realistic about their service requirements, it is possible finally to arrive at a workable situation. It is necessary, however, that this be done with the co-operation of the more senior production management. This co-operation, also, will only be forthcoming if the production management fully appreciate

the effect of maintenance and repair costs on their operation.

Other groups such as rigging teams have to be considered in the light of the workload distribution for them.
Services of a less urgent nature provided by civil craftsmen such as painting, bricklaying, carpentry, glazing and the like can usually be completely centralised with advantage.

3.8 Installation of Minor Plant Modifications and Extensions

Of the additional responsibilities which a maintenance and repair organisation may be required to undertake, new construction work of this sort can be undertaken with advantage.

It would be most unusual if the incidence of maintenance and repair work constituted a steady workload.

Sizing of the maintenance and repair workforce must take account of the known periods of peak workload. While it may be possible to hire additional labour for short periods to cover those peaks, this is not always desirable. For instance, successful execution of the work may require some level of specific training not available on the labour market. It may be also found difficult to get the calibre of men required when needed.
One alternative, to hire a maintenance contracting firm to cover peak work loads, will be discussed later.
The third alternative is to employ a total workforce capable of handling the workload peaks, and provide them with other work in times of lower maintenance and repair workloading.
Construction of plant modifications and extensions provides a ready means of occupying these men. It also has the advantage of providing a team which can be more readily controlled to give a good quality job than most contractors.

It would be a mistake, however, to have more men than is necessary to do more than cover peak maintenance and repair workloading. New construction work itself can include wide fluctuation in workloading, particularly where significant seasonal weather fluctuations occur.

It is usually advisable when such a construction team is formed to retain it strictly under the control of the maintenance and repair organisation. Preferably with the centralised team if it exists. In this way, maximum flexibility in use of the men can be retained and the best possible service to production maintained.

3.9. Use of Contractors

Mention was made earlier of the possible use of contractors to deal with some aspects of the workload of the maintenance and repair organisation. There are a number of circumstances where the use of contracting firms clearly can be advantageous. Other circumstances exist where the decision whether to use contractors or not is not so simply resolved.

Taking the first circumstances. Use of contractors will be advantageous to deal with specialist problems such as infrequent overhauls of propriety equipment. For instance, a major boiler overhaul will be a job which does not arise frequently. The attention it requires demands certain skills which would not necessarily be found amongst a general maintenance crew. If a specialist contracting firm is available within reasonable distance, use of them will avoid the need to train men for skills for which there will be infrequent call.

Other overhauls which may fall into the same category would include turbine or diesel prime movers, generating equipment, and maybe items such as compressors, motor transport and other forms of mobile plant, also specialised packaging or conveying equipment.

Use of contractors is also often advantageous for non-urgent maintenance and repair work when there is time to organise contractors to submit a quotation for the work. The sort of work which most readily falls into this category is related to the civil engineering trades. Building

maintenance and repair work, building and plant painting and decorating, maintenance and repair of yards, roadways, drainage systems and so on. Use of contractors in other circumstances will depend on a number of factors such as workloading, type of plant, location and availability of contractors.

There is an increasing tendancy in a number of countries nowadays for almost complete use of contract labour for maintenance and repair.

General engineering firms are tending to offer this sort of a service to help them over the peaks and troughs of their workload without resort to hiring and firing of employees.

These sort of services can be extremely valuable on occasion to help over workload peaks, particularly when these can be predicted in advance. It is as well, however, to organise the work so that the contract men have a specific part of the job to undertake rather than to mix them with Company employees. Often there is a tendancy toward friction between the groups. Contractors of this sort tend to have special pay structures which, when engaged in work away from their base, gives them a high level of takehome pay. Also their discipline may not match the factory standards both in terms of work control and safety standards. The factory employees will tend to compare the contractors results unfavourably with their own to the extent where industrial relations may become strained.

Plants where maintenance and repair is principally undertaken by contractors tend to be rather specialised continuous process plants. On these plants, maintenance and repair needs are very small during normal operation, and very high during plant shutdown periods. To successfully operate with total contract maintenance under these circumstances it is necessary to have a major engineering company within easy reach which is able to plan its workload to include the plant shutdown demand.

Factories which operate such a system successfully usually are situated in developed industrial areas, usually on or near the coast where there are major ship repair or ship building facilities. Shipyards are usually ideally organised for such undertakings, as the labour force is used to moving from job to job and appreciate the urgencies of shutdown or turnaround work.

It is generally necessary with this sort of system to make long term arrangements with the contractor so that the labour force gets used to the plant and its needs. At the same time, the plant must retain a minimum number of maintenance and repair staff to plan direct and supervise the work, develop preventative maintenance routines and carry out plant inspection and so forth. To meet the small continuous demand for maintenance and repair service during normal plant operation use of contract labour again is preferable, although it may be more expensive than employing men direct. Use of contractors exclusively, avoids the possibility of labour relations problems at shutdown time. Working practices and remuneration are governed by one set of rules only and continuity of contact with the contracting force is maintained.

3.10. Maintenance Staff Duties

We have considered up to now, those responsibilities of a maintenance and repair organisation which involve the provision, organisation and control of the artisan manpower. The remainder of the maintenance and repair organisation's responsibilities are those that involve the staff members of the organisation.

3.10.1. The Supervisor

Any discussion of organisation of the workforce necessarily includes the supervision of this manpower. This first line of management has the specific responsibility of putting these men to work and controlling their efforts.

The supervisory force also has other responsibilities. Being the section of the management team most directly involved with the production and service plant, they have a more intimate knowledge of its shortcomings than most. This knowledge is valuable. It is therefore the supervisor's responsibility to record and feed back any such information to the appropriate section for action.

maintenance and repair activities is correctly recorded against the section of plant or equipment concerned.

Without these two information feedbacks, maintenance improvement activities would have no foundation. A more detailed outline of maintenance and repair costing will be given later.

5.10.2. Technical service - The plant engineer

The next function of the maintenance and repair organisation staff is the provision of a technical service.

This service takes the form of diagnosis of the causes of equipment failure and establishing corrective action.

With equipment failure resulting from normal wear and tear, causes and corrective action can be determined by the workforce themselves or by the supervisor.

With unexpected failure, or in circumstances where the cause of failure is apparent, but the best way to tackle the corrective action is not, a more qualified opinion is required.

It may not always be that the decision required is based on technical grounds. It may be a question of which possible solution is the best on an economic basis.

These are the sort of decisions and technical service which must be supplied by the next level of maintenance and repair management.

This function is carried out by the maintenance or plant engineer. A man with a sound practical background and adequate technical training. In addition to this he also requires a working knowledge of the principles of management. The plant engineer is part of the line team. He has control of a number of supervisors and so carries responsibility for maintenance and repair of some part of the factory.

It is necessary for the plant engineer to be aware of the production situation at any time. His decisions must be based on production needs. However, this must be an overall view. "Production at all costs" must not be his motto. The correct

decision may be at times to incur an extended period of downtime in order to effect a better or more long lasting repair. This would be with the aim of securing the production situation at a later date.

His decisions again must not be made in isolation. He must consult with the production management and with his superior when necessary. Neither must his supervisors be neglected. He has to consider the overall management of his resources. His supervisors have responsibilities and must be allowed to make their own decisions. If they are not consulted, or made aware of situations they will become merely shepherds of their workforce. They will not act with initiative and the plant engineer will have to direct their every move. This level of management of the maintenance and repair organisation is the one at which there is the greatest input of technology into the day to day work. It is essential that the plant engineer organises his group to give himself the maximum time to supply this input where it is required. Inability to delegate responsibility to supervisors means his involvement in every decision and a consequent diminution of the time he can spend on considerations that warrant his attention.

3.10.5. Maintenance Planning

This staff function of any maintenance and repair organisation is probably the one which is most misunderstood and misrepresented of all. At best a planning group can be the cornerstone of the whole organisation. At worst it can be an encumberance and unjustifiable overhead. Which category it falls into depends chiefly on how well its function is defined and what authority it commands. Perhaps use of the word planning itself is wrong. When a planning group exists in a maintenance and repair organisation, there is a tendency for all outside it to assume they have no planning responsibilities. Use of the term Maintenance Preparation Group

First let us decide what we mean by planning. Planning is the process of preparing in advance for some activity which is to occur.

Accepting this definition we can see that planning is something which goes on all the time with just about everyone, in any situation.

Formation of a planning group is a means in a maintenance and repair organisation of formalising the process for a specific part of the organisation's operations.

How much of the operations of the organisation to be dealt with by the planning group will depend on the size of the organisation and the staff strength it can support.

However, assuming that a full scale planning operation can be mounted, the following responsibilities would come within the scope of the group:-

a) Preparation and organisation of operation of long term maintenance and inspection schedules.

b) Provision of a plant inspection and records service.

c) Preparation and organisation of operation of long term plant shutdown maintenance and repair programmes.

d) Preparation and organisation of operation of major repair work.

e) Co-ordination of work loading of a section of the maintenance and repair workforce (including operation of maintenance measurement systems).

Taking each responsibility separately:-

3.10.3.1. Long term maintenance and inspection schedules

It is most often convenient to organise the preparation and operation of schedules of this sort on an overall basis for the factory. When this is so, the planning group, as a factorywide service group, is the logical

place to invest the responsibility.

Short term routine schedules as discussed earlier are best handled on an area basis.

Longer term schedules which involve inspection or maintenance work at a frequency of say six months or more require a reminder system if they are to operate at all. The sort of schedules usually considered are those where statutory legislation requires formal inspection of particular types of equipment on a fixed frequency basis. Similarly, insurance companies may require similar programmes for equipment risks which they underwrite. Other schedules might include inspection of pressure relief devices, electrical interlock systems and switchgear, and critical items of equipment, failure of which in operation may constitute a major hazard to safety or production.

In addition, this service could also include inspections required to plant, the need for which has been identified at previous inspections. Generally, the job of this part of the planning group would be to operate a reminder system to that part of the organisation charged with carrying out the inspection or maintenance operation for the particular item of plant concerned.

They would also be responsible for either recording completion of the operation or reporting to higher authority on non-completion. The establishment of inspection frequencies would not necessarily be their responsibility. However they should be responsible for ensuring that frequencies are established and reviewed periodically.

3.10.3.2. Plant inspection and records service

Here again it is usually more efficient to operate such a service on a factorywide basis and hence the planning group becomes the logical place for it.

This service involves the provision of suitably trained personnel, equipped with the necessary tools and equipment, to determine the period over which items of plant can continue to operate.

The description of the service is deliberately pursued as the determination of the period over which operation can continue.

The major job of any inspection service of this nature is to provide information which allow decisions to be made, in time to safeguard continuity of production.

Dependent on the size of the enterprise and complexity of the operations conducted, the techniques used by the inspection team can vary.

They can include the most sophisticated non destructive testing techniques such as:-

Radiography
Ultrasonic testing
Eddy current testing
Vibration analysis
Television monitoring

Or the simpler but nonetheless effective techniques such as:-

Dye penetrant testing
Magnetic detection
Measurement by gauging, calibering or drill test
Use of test coupons
Hammer or other physical testing
Pneumatic or hydraulic testing
Visual inspection

An essential feature of all such inspection programmes is the need for meticulous recording of test results. This should then be followed up by comparison with previous tests to determine deterioration rate. By this means future life of plant may be estimated. The final stage in the operation is to inform those responsible of the conclusions reached so that decisions on need for replacement can be taken.

It is also necessary to ensure that the inspection frequency is reviewed in the light of findings of successive inspections.

5.10.3.3. Long term plant shutdown programmes

The planning group can provide an overall factory programme service for major plant shutdown maintenance and repair work.

It is necessary with most production plant at some time to arrange for a complete shutdown for major overhaul. Usually experience will determine the frequency at which these shutdowns should take place, although sometimes the frequency will be determined by the statutory inspection frequency of some major item of equipment.

These shutdowns usually represent a major peak workload for the maintenance and repair organisation, and as such need careful planning if they are to be carried out efficiently.

The aim of the overall factory programme should be to include all major plant shutdowns in such a way as to spread the maintenance and repair workload evenly throughout the year.

The planning group must of necessity take the initiative in organising the shutdown programme. There are a number of different considerations which will affect the

stress by the various sections of the enterprise organisation. It is necessary therefore that a central organisation collect and co-ordinate all the relevant data, resolve conflicting viewpoints where possible and refer them for senior management decision where not possible.

The various factors which may have to be considered in formulating the programme might include:-

1. Frequency of statutory insurance or safety inspections
2. Production programme. That is, production capacity versus market demand, seasonal variations, finished stock levels etc.
3. Effect of seasonal weather variations on working conditions in the plant.
4. Availability of in plant labour and outside services.
5. Availability of spare parts.
6. Programmes for plant modification or expansion and equipment delivery position.
7. Findings of previous plant inspections.
8. Experience of the plant engineer.
9. Experience of the plant operational staff with regard to deterioration of production rate and so on.

As the major aim of the programme must be to give the best overall factory service with the available labour force, it is essential that careful attention be paid to exactly what work is done during the plant shutdown. Firstly, all work that needs to be done to return the plant to full operational efficiency or to safeguard operation between shutdowns must be listed. This list

will be compiled from all available sources. The plant engineer, the plant operations staff, the inspection schedules, records and previous plant shutdown records. Secondly, all work to progress plant modifications, improvements or expansion which requires shutdown of the existing plant must be determined. Finally, each item of work requested should be examined critically to determine whether it can possibly be undertaken at any other time than the major shutdown. For instance, some items of equipment can be released for short periods during normal operation, or by short term build up of buffer stocks of materials. Sometimes, slight changes to the means of tying in proposed plant modification can eliminate the need for shutdown or at least greatly reduce the time or work required. By means of this examination, the work to be carried out during the plant shutdown can be reduced to the minimum necessary. Detailed determination of material, manpower and services requirement for each shutdown can then proceed.

5.10.3.4. Major repair work

All major repair work which is predictable on a long term basis will automatically be included in the major plant shutdown programme. Other major repair work will develop without very much notice. This can result from premature equipment failure, mal operation of equipment or perhaps due to heavy loading from a change in production programme.

Some of these requirements will develop suddenly and require immediate attention. These we will refer to later. The remainder of which there is some notice, are those which were referred to earlier as the likely responsibility of a centralised work force.

Such work will often require the organisation of various

services, provision of special machinery or procurement of special equipment or spares.

This sort of work requires more detailed or specialised attention than can be supplied by a local area maintenance group. Again the planning group is the logical collecting centre for such detailed specialist attention to be provided on a factorywide basis.

3.10.3.5. Co-ordination of work loading of a section of the maintenance and repair workforce

This co-ordination service is really the end product of the activities of the various activities of a planning group.

By organisation of long term schedules, plant shutdown work and major repair work, the group is in the position of being able to provide a steady work programme for a significant proportion of the maintenance and repair workforce.

Whether the workforce is divided into area and centralised groups, operated as a series of area forces or maintained as one plantwide group does not basically alter the situation.

It has been established that all maintenance and repair work can be divided into plannable and non plannable work. The term non-plannable work is not restricted to work which it is not possible to predict in advance and make preparation for. Some predictable work consists of minor jobs or local regular routine work. It is usually uneconomical to consider expending planning effort on jobs of this sort. As a general rule, work which can be completed by a supervisor and his workforce without other than routine reference to other parts of the organisation, can be considered to be non-plannable within this definition.

What proportion of the total workload this represents will vary from one type of enterprise to another. However it is unlikely that more than 75% of the workload can be considered plannable. At the other limit, it should be possible to effectively plan at least 60% of the workload. There are two possibilities in considering how the planned and non planned work should be distributed to the workforce.

The first alternative is to engage all the workforce on a mixture of planned and unplanned work. That is to give them sufficient planned work to fill part of their time. The second is to engage part of the workforce totally on planned work and leave the remainder to deal with the unplanned.

While both schemes are used, the second approach is the one most often applied.

The planning group in the second case would have a fixed number of men to schedule work for on a day to day basis.

Their purpose would be to supply to each supervisor, sufficiently detailed information each day on what jobs he is required to undertake. The supervisor must also provide a daily report on progress of planned work to enable the next days work plan to be adjusted where necessary. The reporting and readjusting process is often best arranged on an informal basis between the supervisor and planner concerned. The daily programme can then be produced jointly between them. It is necessary that the programme is jointly agreed. Without such agreement, relationships between planners and supervisors are likely to become strained with both refusing to accept responsibility for any failure to meet work schedules.

Minor emergency work will normally be contained by the workforce not committed to a planned programme of work.

Major emergency work is the greatest enemy of any maintenance and repair organisation.

Such work demands immediate attention and major workforce effort.

It will interrupt and delay planned work, interfere with scheduled programmes and generally lead to inefficient utilisation of manpower and equipment.

The planning group can make a major contribution in reducing the incidence of major emergency work through its inspection programme.

However, allowing that even in the best regulated situations, emergencies will still occur, the planning group again contributes to the amelioration of the worst effects.

By definition, planning is the process of preparing in advance for what may occur.

By being aware of the work situation at any time, a well organised planning group can rapidly decide how best to deal with emergencies with the least effect on the overall situation.

The least important jobs can be stopped, facilities can be diverted with minimum interruption to other situations and on completion of the emergency the threads of interrupted work can be picked up.

Planning organisations are often severly criticised on the basis of the number of times planned work is not finished on time. While this must remain a measure of their achievement, it must be viewed against the background of the responsibility and authority they are permitted to exercise over potential emergency work.

If no attempt is made to reduce the occurrence of emergency work or to question the demands for such work, dislocation of planned effort is inevitable. Perhaps under these circumstances the only value of planning is the ability to reduce the effects of emergency work. Most planning operations are a compromise depending on the views of senior management. None of them can operate with any real degree of usefulness unless they have the authority equal to that of any group whose operations they seek to influence.

Staffing of the planning group will consist of a number of levels. The senior man, should be of a status equivalent to the plant engineer. Like them he should have a sound practical background, adequate technical training, and a working knowledge of the principles of management.

The planning staff themselves should be of similar status to the maintenance supervisors and have had an extensive experience of maintenance and repair work on the plant. It is probably a useful exercise to recruit planning staff from experienced supervisors. Interchangeability of supervisory and planning staff can be a useful asset to the organisation. Inspection personnel again should be equivalent in status to supervisory staff, with perhaps, if the size of the group warrants it, a specialist engineer in charge. Special training will be necessary to familiarise the staff with specialist equipment, but experience of operation and maintenance of the plant concerned is of value.

The remaining duties can be adequately handled by clerical staff.

4. Maintenance Improvement

If any industrial enterprise is to flourish it has to make progress in the face of competition. In addition, the continuous demand for upward progression in living standards requires an increase in per capita productivity.

Consequently it is not acceptable for any part of the enterprise to remain static. There should be a continuous and purposeful effort towards self improvement. This is equally true for the maintenance and repair organisation. The effort towards self improvement is so essential to the future of the enterprise that it is insufficient to leave it to chance or individual inspiration.

It has been the practice over many years to invest the responsibility for improvement of the maintenance and repair organisation with the plant engineer. The success achieved in this way will vary considerably with the personality and temperament of the individual engineer.

The major drawback to this method of approach is the tendency for the plant engineer to be drawn into the pressing considerations of the day to day problems. It takes a good deal of self discipline for him to put aside his immediate problems and set his mind to next year's problems. Additionally, his line responsibilities demand some part of his attention, even under the most favourable circumstances, at frequent intervals throughout his working day. His efforts towards self improvement then will be punctuated by these demands. The difficulties of producing satisfactory results in a reasonable period of time will be appreciated.

There is an increasing tendency nowadays to make the major effort towards self improvement of the maintenance and repair organisation the responsibility of a separate staff group. The group will be referred to as the Maintenance Improvement Group.

It is the responsibility of this group to formulate a programme for improvement of the performance of the organisation.

Input to this programme must be derived from all available sources. The most obvious source is the experience of the plant engineers themselves. While perhaps they cannot give the undivided attention necessary to develop improvement programmes, they are well able to identify areas where improvement is desirable. Very often, as they are technically trained men, they can offer a number of possible avenues of approach towards achieving an improvement. In addition to highlighting the problem areas, the plant engineer is well qualified to advise on the feasability or acceptability of the improvement proposals developed by the Maintenance Improvement Group. It is necessary therefore that the group keeps in regular contact with the plant engineer at all stages of the development of any proposals. Sometimes this can be continued on an informal basis. However, it is often found desirable to set up a formal means of stage approval of development proposals as a background against which to work.

An outline of such a formal procedure is contained in appendix II. together with a suggested means of formally initiating improvement proposals. A means for formally initiating work is necessary if the group efforts are not to be dissipated on following unprofitable lines of investigation. As can be seen in the Appendix, the initiator is required to state what objective is to be achieved and what value the solution will render to the organisation.

Circulation of the proposal within the organisation can avoid the possibility of following up lines which have previously proved unfruitful. It can also draw on the previous experience of others in suggesting likely avenues for investigation.

The formality of filling in the initiation document, at least, forces the initiator to discipline his thoughts and think through his problem.

Supervisors can also be relied upon to provide input into the improvement programme. Their contribution is likely to be less disciplined than their plant engineer might make but is valuable nevertheless. By cultivation of ideas from this section of the organisation, potential major problems can be identified in their early stages.

There is a side benefit from a morale point of view. The supervisor feels able to make a contribution towards improving his own situation and the standing of the enterprise. In addition there will be no more enthusiastic protagonist for the installation and operation of the improved plant or procedure.

Certain pitfalls can be avoided by the formation of a Maintenance Improvement Group. Such pitfalls may exist in proposals for improvement based on impressions from supervisors and plant engineers, not substantiated by real evidence. When involved in day to day work, the immediate problems are the ones which fill the mind. The difficulties in dealing with them are more real than the problems themselves.

It is possible to find supervisors or plant engineers concentrating their efforts on eliminating a problem which, because it occurs infrequently, causes them a lot of bother. At the same time, a regularly recurring problem which occupies a lot of the time of the manpower at their disposal, causes them little concern, because it has become routine procedure.

The writer can recall a major pumping problem which was only highlighted when a particular craftsman left the firm. Until this time, this one man had an almost continuous job tending three pumps. He knew them so well that he was able to keep them in operation without any trouble to his supervisor or the plant engineer. When he left, the pumps suddenly constituted a major production bottleneck and were the subject of frequent major emergency work. On investigation it was discovered that the pumps were operating at 150% of their design conditions, that they were of obsolete design and that cheaper, more efficient and reliable pumps were available on the market.

Another avoidable danger is the temptation for a plant engineer to deal with problems which take his interest rather than those which merit most attention. Identification of which problems merit first attention can be made the responsibility of the Maintenance Improvement Group.

Of necessity, the major criterion for determining the relative merits of a number of proposals will be cost. Maintenance or repair costs incurred in the present situation and what reduction can be achieved by successful solution of the problem, need to be determined.

The maintenance and repair cost records are the source of the required information. If properly organised for the purpose, these records can also supply a valuable service to the Maintenance Improvement Group as source information for their improvement programme.

The major cost components of the maintenance and repair bill can be identified and examined to determine what potential there is for cost reduction. Means of organising the maintenance and repair cost records will be discussed later.

Cost of maintenance and repair alone will not be the only criterion which determines the priorities of improvement work.

It was stated initially that the maintenance and repair organisation

must be recognised as an integral part of the process of production. It is equally important that the organisation itself recognise this and align their efforts to give optimum service to production needs. In many cases this will be achieved by maintenance and repair cost reduction. In other cases the optimum service will result from attention to production problems. Plant availability must be considered in relation to the market situation. With parts of the plant, the major problems may result from the amount of time the plant is not available for production rather than maintenance and repair cost. The Maintenance Improvement Group then must also inspect plant downtime records to isolate improvement work.

A further source of material for the improvement programme is from technical literature, trade exhibitions, proceedings and meetings of professional societies, conferences and all the other communications media which exist in the fields of technology.

The Maintenance Improvement Group should operate a monitoring service on all these sources. In addition they should act as a collecting centre or library for information of this type. It is valuable to ensure that information of value obtained during visits to conferences or manufacturers is formally reported by whichever of the technical staff attends.

Not only should the information be collected, it should be reviewed and potentially valuable ideas isolated. It is then necessary to ensure that the information is brought to the attention of those it will interest and is adequately discussed.

The efforts of the Maintenance Improvement Group should not be restricted to consideration of means of ameliorating maintenance or repair problems alone.

Other subjects worthy of their attention will include:

1) Organisation of the workforce.

2) [illegible]

3) Maintenance workshop facilities.

4) Maintenance equipment tools and techniques.

5) Organisation of maintenance and repair staff.

6) Staff and workforce manning strengths.

Maintenance Improvement Group duties can conveniently be extended to cover other activities by virtue of their role as a technical centre for the maintenance and repair organisation.

Standardisation of plant and materials is a subject which can lead to considerable savings to the enterprise. Selection of plant and materials besides being a matter of cost and availability must also be based on technical aspects of its suitability for purpose.

In collaboration with the purchasing function for the enterprise, the Maintenance Improvement Group can contribute to standardisation programmes aimed at reducing procurement costs or improving material availability.

Formulation of standards for plant and materials will also assist whoever has the responsibility for plant improvement and extension work.

In addition to providing standards for use for plant improvement an advisory service can also be provided to ensure that maintenance and repair needs are considered in new plant design.

Manning of the Maintenance Improvement Group will of course be principally with technically qualified personnel.

If they are to provide and successfully conclude a sufficiently authorative programme for improvement and cost reduction, at least some of the staff must be experienced in the work of the organisation. On the other hand the group is a good starting point for younger members of the organisation to come in contact with the problems and fit themselves for further responsibilities.

The Group will not have any line responsibilities but must be in a position to influence the activities of the line team. The manager of the group should then be responsible directly to the maintenance and repair organisation manager.

4. TRAINING

4.1. Artisans

It is unlikely that any industrial enterprise will find itself situated where there is unlimited labour available for its purposes, suitably trained and experienced in its particular line of business. If the location of the industrial enterprise is in an already industrialised area, labour experienced in the various disciplines required to make up a maintenance and repair workforce should be available.

Nevertheless, even in this situation the maintenance and repair organisation will find it necessary to carry out some form of training for its workforce. As with all the subjects discussed up to this point, the extent to which these procedures will be necessary will depend on the size of the enterprise. With training procedures, the formality of the training will also vary with the size of the enterprise.

With the smaller organisations as a very minimum there will be some form of induction training. This may only consist of a half hour talk between the employee and his supervisor. Following this, the employee will receive training in particular aspects of his work, in one form or another. He will come across plant with which he is not familiar. Particular hazards of materials being used in the process or manufacture will need to be explained to him and so on.

It is of far more benefit to the enterprise and to the employee if an attempt is made to give him this sort of information, rather than let him train himself through his mistakes.

As the size and complexity of the enterprise increases so does the training need.

Although an enterprise may be fortunately placed so that sufficiently trained maintenance artisans are available to them, it will not be long before training needs arise. Training needs of maintenance and repair artisans can arise from a number of sources.

Induction training of new employees.

Training of new employees inexperienced in the particular circumstances, plant orprocess hazards of the enterprise.

Training in basic engineering skills for non-skilled employees or for youths entering industry for the first time.

Training the existing workforce to extend their skills.

Training the existing workforce to meet the needs of new plant or new techniques.

Discussing each aspect in turn:

4.1.1. Induction Training

Induction Training is normally a fairly straightforward business of introducing the employee to his workplace. He needs to know where his workplace is, who his supervisor is, what his hours of work are, where toilet and canteen facilities are located, what his job and the purpose of his work group is and how it fits into the general operation of the organisation.

Other information he requires to know include the rules he must obey, and what the consequences of failure to observe them might be. He will be interested in knowing what pay he is entitled to, what bonuses or premium payments he may qualify for, what additional benefits he derives from his employment. If there is any form of

to work through sickness. The ambitious employee will also be interested in what chances there are for his advancement through the organisation or the enterprise generally. An important aspect of his induction training should be to introduce him to the safety practices and rules which are observed in the enterprise. Safety at work will be discussed in more detail in a later section of the paper.

The timing of the various aspects of this induction training is worth considering.

Some aspects are obviously necessary to deal with before the employee is actually set to work. This should be held to a minimum, he will have enough on his mind starting a new job without overloading him with too much information. The remainder of the subjects can be dealt with after he has had a few days to settle down and become familiar with his surroundings.

The best person to present the induction training to an employee is his supervisor. This gives both the opportunity of getting to know one another and gives the supervisor the opportunity of gaining the employee's confidence. However, it may be more convenient to organise some parts such as factory safety rules, welfare benefits and so on as group sessions with a number of new employees. The information being presented by the safety and personnel organisations respectively. These group sessions however must only supplement and not replace the supervisor's induction training.

4.1.2. Plant training of new employees

This training refers to the familiarisation of already competent new maintenance and repair artisans with features of their new workplace they have not previously encountered.

'need to know' basis.

The supervisor again has a responsibility here. It is the supervisor's job to discover exactly to what extent the new employee or employee new to his area of responsibility is familiar with the plant or situations he will meet in his new job.

The supervisor is aware of the needs in his area and can, with experience, produce a checklist against which he can compare the new employee's experience.

Depending on the work needs it may be necessary for the supervisor to set about the training right away in some aspects. This training may consist of some instruction from the supervisor himself. He may put the employee to work with an already experienced employee (the "sitting next to Nellie" approach), or he may use a combination of these or other more sophisticated techniques, depending on the requirements. However, whichever method he adopts, it is always necessary for him to be aware of what instruction has been given and more important, to test out the employee concerned to discover whether the training was effective.

Some of the training needs identified may be general needs applying to a number of employees. If this is so, a group session can be organised. It is probable that these needs will become well recognised after a while and a standardised programme or series of training sessions can be drawn up.

There is one thing these and other programmes aimed at imparting skills must have in common. All such training must first instruct, this should be followed by demonstration and finally should be completed by the person to be trained, practicing the exercise to be learned. This enables the instructor to measure the effectiveness of his instruction and to reinstruct where the trainee has not absorbed the instruction first time.

4.1.3. Basic engineering skill training

The need for training of this sort will vary considerably with the situation of the enterprise.

Where skilled men are in extreme short supply, a major training programme may be necessary.

In easier situations it will probably still be advisable to undertake some training of this sort, particularly with youths with a view to providing skilled men for the future.

The needs of such a training programme will depend on the locally accepted application or division of skills between trade groups. Consideration of these factors is beyond the scope of this paper. However, Appendix III contains an example of a listing of skills required by a mechanical fitter prepared as a starting point for a training programme.

Training of this sort can involve a fairly substantial capital outlay in provision of training facilities and full time training staff will be required. Every advantage should be taken of national or local schemes or facilities for such training. Once the basic skills have been learned, a period of familiarisation and practice in the skills will then be necessary under suitable supervision on the factory. A programme for training youths, based on the listing of required skills is exampled in Appendix IV.

4.1.4. Training for extension of skills

A common feature of the workload of all maintenance and repair organisations is its variability and continued change.

If the organisation were to be set up to deal with every possible eventuality in the best possible manner, the organisation would become a complete engineering enterprise in its own right.

Obviously this situation would be ridiculous. The aim should be to produce a flexible organisation which can tackle a wide variety of work. Machine tools and equipment should be general purpose rather than specialised. Similarly, artisans generally should have a wide variety of skills and not be restricted to single specialist disciplines.

Industry in countries where development took place many years ago have suffered and in many cases are still suffering considerably from this sort of situation. Engineering crafts developed in a specialised manner and were adopted into industry.

There is a good opportunity for developing countries to avoid the worst effects by learning by others' mistakes. Every effort should be made to avoid building up artificial barriers between groups of workpeople based on the jobs they usually perform. Understandings must be reached with the workpeople that jobs will be performed by people suitably trained to do them. Additionally, these understandings must include the premise that training can be made available to whoever can benefit from it when the need arises.

In this way, flexibility of use and mobility of the maintenance and repair workforce can be retained.

Depending on the sophistication of the equipment employed

in the production process, it may be necessary to build up certain specialist skill groups. Even here though some flexibility in the arrangements for recruiting additional personnel to the section should be carefully considered. Training for extension of skills assumes some importance in this context of flexibility and mobility of the maintenance and repair workforce. Techniques employed in such training again will depend on the number of people requiring training at any one time and the complexity of the skill to be acquired.
Training can vary from shopfloor instruction by the supervisor or a nominated artisan to classroom or training workshop sessions. The important feature of instruction, demonstration and practice must remain a common factor whichever means of training is adopted.

4.1.5. Training for new plant and techniques.

This training need is self explanatory and most of the foregoing remarks on means of training are equally applicable to this case.

4.2. STAFF

The various sections which go towards making up the staff side of a maintenance and repair organisation will have various needs in terms of basic training and experience.
Again it is not possible within the scope of a paper of this nature to go into detail of all aspects of training requirements.
It is possible however to outline the background from which the various staff grades can be drawn and to indicate what further training needs may be required.

4.2.1. Induction Training

As with artisan employees, some form of induction training will be necessary. Because of the wider scope of duties encompassed by staff personnel, particularly as one passes up to the higher levels, the induction training programme will assume a much wider scope.
All the features of the simpler programme will remain, workplace, working conditions, rules, pay structure, additional benefits and so on. Additional information on the structure of the organisation and the enterprise and the interdependance of the various sections will be necessary. Administrative procedures, data collection and processing methods and general management policy and operation will also feature to a greater or lesser degree at some time during the induction period.

4.2.2. Supervisor training

In this context the background and training of the supervisor and any planning staff follow the same pattern as the author believes in interchangeability as far as is possible between these groups.
Even where the personality of a member of one or other of these teams precludes interchangeability, a thorough grounding in the other's responsibilities is essential for adequate performance of his own duties.
The most satisfactory and successful means of recruiting supervisory personnel is from the workforce.
One of the major demands in terms of background and training of the supervisor, the first line of management, is familiarity with skill requirements of the maintenance and repair workforce. Another almost equally valuable asset is familiarity with the plant.

Experienced members of the workforce fill this specification most admirably. As the major requirement for a supervisor is his ability to put the workforce to work, and to produce the necessary results, it is obvious that this background is not all that is necessary to produce the complete supervisor. In this context, the author can do no better than refer to a paper presented to The Institution of Plant Engineers with the title "The Supervisor". See Appendix .V.....

4.2.3. Technical Staff Training

The background and training requirements for the plant engineers must be carefully considered. It is this staff group which besides carrying out an essential function, also provides the basis for the future of the organisation. It is perhaps well to not only consider the plant engineer in this context. The term as used up to this point has been restricted to one who performs a line function and to whom the supervisors report.

In the broader understanding of the term, a plant engineer is one who has responsibility for design development operation, maintenance and repair of plant. Within this definition one can include the majority of the technical staff that have been discussed previously. They are:-

The plant engineer

The maintenance improvement engineer

The specialist engineers

The senior maintenance and repair management.

The background and basic training required for personnel to perform all these functions has the same or similar basis. The basic essentials consist of a combination of technical education and practical experience.

The level of technical education required varies with duties required to be performed. Obviously someone engaged in design work will require a fairly high level of technical education.

Generally a minimum level of attainment will be sufficient for most duties. This level of attainment is specified by the entry requirements to professional bodies which cater for plant and various other specialist engineering disciplines. The technical education levels may be achieved through university or full or part time technical college education.

This fact makes it possible for advancement of personnel from the workforce as well as entry from university or technical college.

The practical experience referred to is also considered an essential requirement. This is again clearly indicated by the entry requirements for the professional bodies referred to.

As far as personnel who have advanced from the shop floor are concerned, they are fully qualified in this respect. Most university courses nowadays which cater for engineering students also generally provide for a period of training in industry.

On this foundation, as the young engineer progresses through the industrial environment, he will build experience and fit himself for jobs of increasing responsibility. If he is fortunate he will join a progressive company with a policy of training for its potential senior managers.

The very least that the enterprise should provide is training in the essentials of management, and modern management techniques. This training should be planned and should be relatable to the management policy of the

young engineer, to attend a management course and on return to the factory to discover that his immediate superior is unaware of, or disinterested in, applying the concepts presented at the course.

There is often a good case for sending the senior managers on the course first, following up with the same training for successively lower levels.

5. MANNING OF STAFF FUNCTIONS

If the maintenance and repair organisation is to be well equiped in terms of personnel to carry out its function adequately, the need must be recognised and action taken to meet it.

Background and training of staff personnel has been discussed. Training must however be carried out on a planned and purposeful basis.

The first stage in the process is to decide what sort of an organisation is required, and what positions are required to be filled.

5.1 At this stage it may be helpful to write job descriptions for the various posts. These descriptions must describe the responsibilities which the job carries and also the duties which are required to be performed. Some typical job descriptions for maintenance and repair staff functions are attached in **Appendix IX.** They relate to an organisation concerned with maintenance and repair of chemical process plant.

Care must be taken in producing job descriptions that the key responsibilities are identified.

A satisfactory method of producing these within an existing organisation is to get the existing staff to write their own. They should be supplied with a questionnaire designed to encourage them to view their jobs critically. This exercise will make the incumbents think about what they do and at the same time will provide valuable information to senior management.

The answers to the questionnaire will reveal any discrepancy between what senior management thinks their staff is doing and what they are actually doing. It should also help to identify where re-instruction with regard to responsibilities might be necessary.

writing of the job description can then be completed by summarising the answers to the questionnaire. It is advisable at this stage for discussion of the questionnaire to be carried out between the man concerned and his immediate superior.

The aim here is to resolve what differences there may be in their view of the job.

Though it is generally accepted that job descriptions should exist for every staff function within an industrial enterprise, there are certain hazards that must be guarded against.

Indeed it is felt by some organisations that the hazards are so great that they write descriptions and keep them away from the person performing the jobs concerned.

This however is an extremist attitude and provided the situation is kept under control, the author believes that well written job descriptions are of great value.

The major hazard referred to is, of course, that the job description is viewed by the incumbent of a post as the limit of what is required of him. This sort of person is not an asset to any organisation. This approach tends to destroy morale and team spirit, particularly if the person concerned is in a position in control of others.

A job description must be seen as the minimum that is required of the incumbent if he is doing his job adequately. Reward for good performance should be based on achievement in excess of the job description requirements. Armed with an understanding of the sort of organisation required to undertake maintenance and repair in our enterprise and also with the job descriptions, we can now consider how we are to man the organisation.

.2. It is not often that the situation arises where a completly new organisation is required. More often the situation is one of re-shaping an existing organisation.

Whichever is the situation, the problems remain somewhat the same.

A man must be found with the required background and training to fill the post. If the man is not available within the organisation he must be recruited from outside.

It is seldom that anyone will fill the specification fully in every detail. The important thing is that anyone selected, with perhaps suitable training, can develop to the stage where he can perform the job required of him.

The requirement that a man can develop to fill a post adequately, leads on to a most important factor to be considered in selecting personnel. That the person selected has the personality and physical qualities to suit the job requirements.

With regard to physical qualities, good health is of course always desirable. Dependent on the industry and the duties to be performed various other physical characteristics may be desirable. For instance defective vision can be a serious hazard in any job where the person is expected to spend time in areas with moving machinery, hearing defects where mobile equipment is in abundance, fear of heights or tendency to dizzyness in jobs requiring the climbing of scaffolding, claustrophobia where entry to confined spaces is required and so on.

Personality is a much more difficult thing to judge but nevertheless an attempt must be made to match the personality of a candidate to the job required of him.

With maintenance and repair work, two particular personality characteristics are necessary, because of its role in an enterprise. These characteristics are a sense of responsibility and the ability to recover quickly from disappointment or adversity.

The incidence, particularly of repair work, cannot easily be regulated. The demands of production also generally tend to require attention to trouble whenever it occurs.

Maintenance and repair management must often depend on the sense of responsibility of its engineers to apply themselves to the job whenever it occurs and to follow the job through to completion, whatever this requires

in terms of time. The engineer of course must be adequately compensated for his efforts, but money cannot buy this sort of service if a sense of responsibility is absent.

Maintenance and repair work has other features, which doom the personnel in the organisation to frequent disappointment. Neither can they expect much recognition of their efforts from outside the organisation.

Maintenance and repair is a constant battle with deterioration.

The deterioration the organisation fights is a continuous process resulting from age, fair wear and tear, misuse, deliberate abuse and weather conditions to name a few circumstances that readily come to mind. This is a battle which is never won. At best, the organisation can derive satisfaction from the effectiveness of its delaying actions.

That plant will ultimately fail is the inevitable fact which the maintenance and repair organisation faces. When the failure occurs, more often than not, the production staff view this as a failure by the maintenance and repair organisation. In their anxiety to resume production they will seldom recognise even outstanding effort to return plant to service. Because of the exingencies of production, often a job cannot be completed in the best "engineering" manner. Compromise between what the maintenance engineer wants and what he must do is often necessary. He will often see his best efforts reduced to nothing by the use to which the plant is put and he will then be expected to pick up the pieces and start again.

With a man of the wrong temperament or personality these circumstances can quickly result in frustration, dissatisfaction and in the ultimate even to mental or physical illness.

The maintenance engineer then must be imaginative but confident in his own ability. He must be able to derive satisfaction from carrying out his duties in a responsible manner. He must be able to accept criticism without worry but at the same time he must not completely ignore the fact that criticism has been made. He should use this as a basis for a critical appraisal of his own performance with a view to improvement.

As stated previously, such characteristics are difficult to determine. However, tell-tale signs of the effects of the job strains can often be

detected before serious harm to either the person or the organisation occurs. If this happens, the person can be transferred to other functions within the organisation where these strains are not so great.

Generally it is the plant engineer who carries the brunt of this effect. The Maintenance improvement engineer will not be subject to the same pressures. The job characteristics described do not have any ill effect at all on someone suited to them. In practice a plant engineer who is temperamently suited to the job derives great satisfaction from it, and will not readily change to other responsibilities.

In manning the organisation one must take all these factors into account, making the best compromise possible. Training needs to develop personnel better to carry out their duties must be identified and the necessary training organised.

5.3. This is the first part of the manning operation. The second part is to consider the future needs of the organisation.

The future plans for the enterprise may require an increasing maintenance and repair service.

Some members of the organisation may be due to retire.

Certainly some members of the organisation will be looking for the opportunity to take on increased responsibility.

Apart from these predictable or visible circumstances, allowance must also be made for the unexpected. Personnel may resign, become ill or be involved in accidents.

At any time there may be a need to fill a key post in the organisation. Plans must be laid in advance to deal with such situations. Possible successors to the key posts must be identified. Training and development of such people must then be organised to fit them for these posts.

If suitable people are not available, recruitment of people with the necessary future potential must be the policy when the opportunity arises of engaging new staff.

6. MAINTENANCE AND REPAIR FACILITIES

Having considered the organisation, manning and training of the maintenance and repair personnel we can now consider the facilities they require to do their work effectively.

6.1. Workshop Facilities

Workshop needs will vary considerably with the size and disposition of the maintenance and repair organisation and also with the type of enterprise it serves.

It is possible, however, to discuss guidelines which should help in deciding what the needs are for any particular enterprise.

Discussion of the possibility of organising the workforce into centralised or area groups touched on the subject of workshop facilities and gives us our starting point.

Maintenance and repair work can be divided into two main groups.

Firstly that work which is carried out on the plant which doesn't require the equipment to be transported from its operating situation.

The second group is that which requires the work to be carried out on plant removed from its normal operating position.

Most maintenance and repair jobs require a combination of both on and off-site work.

The first group the on site work will be discussed under the heading "On site facilities".

The second group of work, that conducted away from the plant operating situation will normally best be carried out in a workshop.

6.1.1. Area Workshops

If the maintenance and repair workshops is divided into area and centralised groups, area workshops will almost certainly be desirable. Even in the circumstances where the total workforce is concentrated into a centralised group, area workshops may be desirable.

The primary requirement here is for a designated place where maintenance men can do benchwork jobs.
Such a workshop then must be provided with suitable workbenches equipped with vices, suitable for the type of work to be undertaken.
Other facilities will also be found necessary.
These may include:-

Fixed floor or benchmounted grinding wheels

Pipebending facilities.

Powered screwing machine.

Turning facilities.

Fixed floor or bench mounted drilling machines.

Portable powered tools.

Hand tools.

Lifting equipment.

Spare parts stocks

Engineering material stocks

Special clothing stocks

Storage and drying facilities for clothing

Drawing storage facilities

Office facilities - desks, files and telephones.

Washing facilities

Messroom facilities

Not all area shops will require all the facilities referred to and in the sophistication of the facilities will vary considerably. Appendix ....VI.... contains lists of typical facilities contained in area workshops in a fairly large chemical processing factory.
Some explanation of the purpose of the facilities listed is perhaps relevant.

6.1.1.1. Grinding wheels are probably the most commonly used powered engineering tools and are probably used equally by most trades. In general they will be used for the rough removal of metal and for sharpening tools. Whenever it can be justified a fixed floor or bench mounted unit should be provided. It is more readily available for use than portable equipment and generally safer to use for most purposes. The hazards associated with use of grindstones are well known and well documented.

6.1.1.2. When area maintenance and repair work is likely to include pipework, normally a hand powered hydraulic pipe bending rig with a capability of bending up to 3" bore piping is suitable. Powered bending equipment would not normally be justifiable for the small scale needs usual to a small area group.

If pressure testing is required a small hand operated hydraulic test pump may be justified.

6.1.1.3. It is often the practice to use screwed pipework on small bore low pressure systems. If this is the case and work load warrants it a small powered pipe screwing machine can be a useful asset.

6.1.1.4. If there is a frequent need for turning small parts or skimming seatings and so on in a particular area a small lathe may be justified. This should be for general use rather than being manned full time by one man. Normally it is unlikely that area workload needs would keep the lathe in sufficient demand to justify its installation.

6.1.1.5. Drilling facilities are almost certainly necessary in any area maintenance workshop. Fixed floor or bench mounted units fitted with a suitable work vice and with a capacity of up to $\frac{1}{2}$" diameter are usually most suitable.

6.1.1.6. A range of portable power tools can probably be justified for area workshops, particularly if "on plant" power supply facilities exist. Suitable power supplies in the workshop will also be necessary to gain most advantage from the tools.

Compressed air powered tools generally have a greater power to weight ratio than electric tools. They also have distinct safety advantages both in their absence of electrocution hazard and the capability of their use in areas where fire or explosion risks exist. Because of the capital cost of supply of compressed air for tool purposes it is more likely that electric power will be available. Use of portable transformers and low voltage tools will reduce electrocution hazards or alternatively portable monitored earth systems can be used with higher voltage and consequently more powerful tools.

Most usual tools found suitable for this sort of use include drilling machines, grinding and sanding machines, hammers and impact wrenches.

If neither electric or pneumatic power are available on the plant, battery powered tools can often be useful.

6.1.1.7. The effectiveness of the maintenance workforce will be greatly influenced by how well they are equipped. Hand tools should be good quality and suited to workload needs. Where justifiable personal sets of tools for the workforce have the advantage that the men concerned will look after them.

with tools in less frequent use, a shop tool stock will be necessary. For example for special spanners, heavy hammers, stocks and dies, long tape rules and so on.

6.1.1.8. Lifting equipment will be required for many operations. It is often useful to have the more frequently used items available in the area workshop. A light hand powered hydraulic crane can be very valuable and possibly also a hydraulic scissors platform, capacity of both about 1 ton. Lifting blocks say up to $\frac{1}{2}$ ton capacity and pull lifts up to $1\frac{1}{2}$ ton capacity are inexpensive and useful site tools. A variety of suitable slings, eyebolts, cleats and any special lifting strongbacks will complete the requirements.

6.1.1.9. A stock of spare parts which are in frequent demand can usefully be retained in area shops to avoid delivery delays from the main stores. Stocks should be the very minimum necessary. Certainly no more than would be required during an average week. Anything more than this will result in taking up valuable working space and increasing spares inventory by duplicating the function of the main stores.

6.1.1.10. As with spare parts, a stock of general engineering items in regular demand can be a useful asset to an area workshop.
Again stocks should be limited to about one week's supply.

6.1.1.11. Certain maintenance and repair operations may require the wearing of special clothing. For example, gas or dust masks, eye protection, gloves, acid proof suits, rainwear or perhaps clean room clothing for dust free operations.

A minimum stock of such items should also be considered.

6.1.1.12. It will be necessary for the workforce to have facilities for storage of their street clothing while at work. This storage can also be used for storage of work clothing during off duty hours if suitably adapted. Dependent on climatic conditions it is often useful for the storage area to be adapted to drying this clothing should it become wet.

If central facilities are not provided it will be necessary to supply them in or adjacent to the workshop.

6.1.1.13. Facilities for storage of plant detail drawings and for spreading them out for examination are necessary. Use of a workbench for examining drawings is not usually suitable. Drawing stocks should be restricted severely to those likely to be required regularly or in an emergency. Original drawings should not be retained in any workshops. Copies only should be used.

6.1.1.14. Operation of an area workshop will usually require some basic office equipment for the supervisor to use. He will need a desk top and a chair to use for his administration and reporting work. A file for instructions, notices and report forms of various types will also be necessary.

A telephone for factory internal communication is necessary.

A noticeboard for general workshop reference will also be necessary. Often a blackboard and chalk will be found to be useful for discussion purposes.

6.1.1.15. If central facilities are not provided, washing facilities will be required in or adjacent to the workshops. Provision of a suitable hand cleaning material for use with cold water can be useful. However, the additional provision of hot water supplies is preferable. Disposable paper towels will avoid the considerable problem of laundering. They can also serve the dual purpose of being available for general use in the workshop.

6.1.1.16. Again in the absence of central facilities, provision of mess room facilities at or adjacent to the workshop may be necessary.

For the purposes of effective control it is usually preferable to have the clothing, washing and mess room facilities visible from the workshop. Either a segregated area of the shop or a partition with sufficient windows will meet this need.

6.1.2. Central workshops

As mentioned during discussion of organisation of the workforce it is usually convenient to concentrate high capital equipment in centralised areas where maximum use of them can be made.
Due to the frequent needs of major work to involve the services of a number of work groups, it is preferable to group all the centralised workshops together.
For example, a job may involve fitting, turning, welding, sheetmetal working brickwork and painting. Grouping the shops together will limit the amount of transporting and walking involved.
Grouping of the engineering stores and spares stocks and also welfare and mess room facilities in the same area is also desirable.
The location of this central complex should also be considered in terms of its accessability from the plant. In addition, positioning and size of entrances in relation to roadways, size of plant likely to be transported and transport facilities likely to be used should

be considered.

Provision of storage facilities for plant awaiting repair, delivery of spares or reinstallation should also be taken into account.

Let us now look in a little more detail at the sort of workshops we might need. Appendix ....VI... contains details of the facilities in the central workshops complex at a chemical factory.

6.1.2.1. Machine Shop

It is unlikely, except in a very large works covering a large area, that it would be justifiable to have anything other than small or special purpose machine tools in area workshops.

In most circumstances it is advantageous to concentrate the machine tool facilities in a central shop. In this way maximum use can be made of the tools and in most cases it is possible to keep men fully employed on operation of individual machine tools. Use of specialist tradesmen in this way has advantages in raising the quality of work produced from the machine tools and also extending their useful life. The machine shop will be principally engaged in the manufacture of spare parts from stock material. In addition there will be work involved in the repair of existing equipment. Boring out parts for bushing, preparing ends for welding and so on. Generally the workload will be varied and unpredictable.

Because of the variability and wide range of machining operations likely to be required to satisfy all the needs of maintenance and repair, the machine tools should be capable of a wide range of use.

Lathes certainly will be necessary. In all probability two ranges of size will cover most needs unless there is a particular piece of plant to be maintained. The aim in selection of lathes should be maximum flexibility in speed

range covered and screw cutting facility, maximum length between head and tailstock and maximum swing over the bed.

A pillar drilling machine again will almost certainly be necessary. The maximum size of drill required will be governed by the work requirements. For instance, the maximum diameter of heat exchanger tube in use may be the criterion. Generally 1½ inches diameter should meet most cases. Again speed range should be as wide as possible to cover a wide range of materials to be worked on.

Siting of the drill should give maximum access with maybe a pit included within the arc the drilling head will cover. The pit would normally be boarded over and only uncovered when required.

Metal planing or shaping machines are usually a useful attribute and also milling machines. With all these tools the aim should be to obtain a machine with a wide range of use and adaptability.

Other equipment which will be necessary include floor or bench mounted grindstones, both for general use and one especially for tool grinding purposes. An attachment for drill grinding is also useful.

A means for cutting off bar stock will also be necessary. Depending on the size of the shop, either a powered hacksaw or a circular cold cut off saw will be most useful. Abrasive cut off machines, hand saws and fusion saws generally will not produce a sufficiently square cut for workshop use.

Depending on the sort of work required it may also be found useful to use vertical or horizontal borers, surface grinders or other specialised tools.

If these sort of tools are not in frequent demand and there are local machine shop facilities outside the factory, it

may be more economical to contract the work out. A thorough examination of the likely range of work required and local facilities should be made before equiping the workshop.

Equiping the worksnops complex with power supplies greatly increases the flexibility of tneir use.

Provision of welding power sockets, monitored earth electrical supplies or low voltage supplies, compressed air and possibly fuel gas can be used to advantage.

Lifting facilities in the form of either a gantry crane serving the full length of the shop or jib cranes sited over particular machines will almost certainly be necessary. The choice of crane, capacity and whether power or hand operated will depend on the workload to be handled.

If a gantry crane is to be made use of, it may be advantageous to site shops in line and allow for passage of the crane from one shop to the next. An extension through an end door onto an open unloading area will also be of great advantage.

6.1.2.2. Fitting Shop

It is often convenient to combine the machine shop with a fitting shop. This shop will principally be engaged on the dismantling and reassembly of items of plant. The dismantling reveals what spares are required to return the unit to working condition. Often machining work will be necessary to manufacture special spares or to bore out housings and make bushes. With the machining and fitting work under the same supervision, planning of throughput and machine loading becomes a simpler operation.

The main features of the fitting section of the shop will be sturdy benches with suitable vices. Equipment will

be required for degreasing and cleaning parts and possibly sandblasting.

If equipment is likely to be very dirty externally on leaving the plant, special facilities will be necessary for cleaning before delivery to the workshop. Gas freeing can also be carried out in the same location.

The requirements here are an open area, with good road access, steam and water supplies, good drainage facilities with the means of trapping solids to avoid drain blockage. If oils or chemicals are likely to be contained in the run off to drains, consideration must be given to the means of its safe disposal.

Within the shop itself there is a need for an open floor area in which to carry out dismantling operations on larger items which cannot be mounted on a bench. This area should be served by lifting facilities. A small power or hand operated hydraulic press is an extremely useful tool for this workshop both to aid in dismantling and re-assembly of parts.

In maintenance and repair work, good use can be made of thermospray systems for building up worn parts.

It is often useful to put aside an old lathe for this work. If possible it should be located away from the other machine tools. If this is not done, the sprayed material may find its way onto machine beds and so on, producing accelerated wear.

6.1.2.3. Fabrication or Welding Shop

If it is possible to site shops in line to take advantage of a gantry crane, the welding shop should be sited next to the machine/fitting shop.

It is usually convenient to combine facilities for

fabrication of equipment with the general welding shop. as the fabrication will often include sheet metal work, facilities and craftsmen for this purpose should also be included. It will be found that the major part of the welding work required can be dealt with by electric arc stick welding methods. However, some use will be made of oxy-acetylene welding particularly for sheet metal work. In addition gas shielded arc welding such as argon arc will be useful for non ferrous applications. Other techniques which it is usually necessary to have available will include soldering, brazing, leadburning and almost certainly hot gas welding for thermoplastic materials. Oxy-acetylene burning facilities will also be necessary for plate and bar cutting and preparation for welding. If a significant amount of vessel fabrication is carried out arc gouging equipment will also be useful. Usually the maintenance and repair welding workload seldom consists of jobs of such magnitude that the speed of applying weld metal plays any appreciable part in the cost. Although CO_2 or argon shielded M.I.G. welding techniques can result in appreciably reduced times in completing a welded seam as compared to stick electrode welding, for general use it is seldom advantageous. With short run and anything other than easy to get at seams, the time lost in setting up outweighs its other advantages. However, if there is likely to be a regular workload such as frequent vessel fabrication or large bore pipework fabrication this type of equipment will prove advantageous.

In addition to shop welding, there will be a need for on site welding work. The ideal arrangement would be to have welding power outlet sockets installed throughout the factory. Mobile welding transformers can then be plugged into these as required. If this is not feasible

of self powered portable or mobile sets will be necessary. The ventilation system in the welding shop must be given particular attention in order to reduce fume nuisance. Apart from the normal fume production from welding and burning operations, with equipment for repair, there is often oil and chemical contamination to be dealt with. For 'on site' welding work there will also be a need for ventilation or exhausting equipment in some cases. Electric or compressed air powered fans or compressed air powered air movers will meet this need. Sheetmetal working equipment should include a guillotine, hand or power operated dependent on workload, folding, rolling and shearing machines. Space will be necessary for material storage, a marking out area, a fabrication area, workbenches for welding and sheetmetal working. The welding workbenches should be suitably screened to prevent arc flash injuries. Portable screens will also be necessary for general use in the workshop.

A useful asset might be a small furnace which can be used for hardening tools and small components. It is usually most convenient to site this in the welding shop where the ventilation system can cope with the heat load. A properly organised tool and material store will also be required to serve the needs of both the machine and welding shops. If the shops are of any size, a full time storekeeper who can service and carry out minor repairs can usually be justified. As the sort of equipment contained in a store of this kind is easily carried and can usually readily be sold, good security is essential. Besides easily accessible, dry, clean racking, the store should contain heated facilities for storage of the coated stick electrodes required for welding.

6.1.2.4. Woodworking Shop

The need for woodworking facilities will vary considerably with nature of the factory to be served.

As a minimum there will be a need for a workbench and timber store and a circular saw. If there is an appreciable workload, a bandsaw and planing machine may be required. Whichever is the case, a selection of portable tools will be useful.

The shop should then be supplied with the appropriate, suitably protected power supplies.

In this shop also, an extraction system will be necessary. In this case to remove sawdust.

6.1.2.5. Field Workshop

If the maintenance and repair organisation includes a centralised workforce to be used on factory wide work, it will be necessary to provide workshop facilities for them.

While on site they will be able to utilise facilities available in the area workshop nearest to the worksite for minor work. However, as the centralised force will be engaged on the more major repair work, they will require rather more sophisticated workshop facilities than are provided in area workshops.

For pipework fabrication, a powered pipe bender, powered screwing machine and a cut off device. Again, either a powered hacksaw or cold cutting circular saw is preferable. Additional equipment may be required dependent on the size of the workforce.

A cold flanging machine is a most useful tool for pipework fabrication. With this, flanging of pipework can be carried out without the need for welding services.

To use this machine effectively pipework material must be

of consistent outside diameter, it should be cut off with square ends and be rag free. Providing these conditions are met, sound flanged ends can be produced in a few seconds for most services up to 150 psig. Steelwork fabrication is another likely service required from this workforce. The requirements here are less exacting. An abrasive cut off machine or a band saw will usually be sufficiently accurate for this work. Of course an additional machine would only be necessary if the workload justified it.

With steelwork fabrication a pillar drill with a capacity of up to 1" diameter may well be found necessary. Steelwork requires a good level surface with preferably a lifting jib with capacity of approximately $\frac{1}{2}$ ton. It is often useful to include welding facilities in this shop with perhaps one or two welders employed full time. Despite the value of a flanging machine, there will still be a constant need for welding for pipework. Pipe brackets and steelwork will also provide a regular welding workload. The welder should be allotted a section of the workshop with a bench, some floorspace and provided with suitable screening.

Associated with the workshop there should be storage space. This space is needed for holding stocks of tube and steel sections for immediate use. Stocks should be replenished on a weekly basis to avoid the need of journeys to the stockyard whenever a job comes up. Space is also required to store completed work awaiting installation. This storage area does not necessarily need to be in the workshop. All that is necessary is that it is within easy reach of the shop doorway and is readily accessible by road.

Preferably the area should have a good concrete surface

The necessity of providing cover would depend on the nature of equipment likely to be stored, the prevailing weather and the periods of time of storage likely to be involved.

6.1.2.6. Electrical workshop

Specialist groups such as the electrical workforce because of the relatively small numbers of men involved are usually best organised on a centralised basis. Occasionally where particular circumstances make it worthwhile small area workshops may be justified. Equipping of such area shops will be basically the same as for the general maintenance workshops. Additional items related to the specialist activity will of course be necessary. A conduit vice and bender may be necessary and also crimping tools. Soldering facilities and means of melting sealing compound will almost certainly be required as also will be portable continuity testing devices. Spare parts and supplies again will be related to needs of the area served by the workshop.
As with the other centralised shops, the central electrical workshop will contain the more sophisticated items of equipment. This will include fixed facilities for continuity and earth testing. Lifting equipment for electric motor handling and possibly facilities for motor rewinding if this service cannot be obtained locally.

6.1.2.7. Instrument workshop

Only under very special circumstances would it be justifiable to establish an area workshop for instrument work. Generally instrument maintenance requires fairly sophisticated and expensive testing equipment. In addition clean working conditions are essential if

maintenance is to be effective. The types of equipment required will depend very much on the instrument systems which it is required to maintain.

With increasing use of electronic control the training needs of instrument maintenance men are increasing, and also the sophistication of the testing and calibrating equipment. However, the difficulties can be eased enormously if standardised maintenance procedures are developed and employed.

Despite the increasing use of electronics, pneumatic controls still represent the major part of the systems in use. Even with these systems, use of standardised maintenance procedures will reduce the training and maintenance problems appreciably.

6.1.2.8. Rigging Stores

Rigging work, that is, the more specialised operations concerned with the moving of equipment, will all be carried on around the factory site. There will consequently be no need as such for a workshop for riggers. However, if a special team of lifting specialists is necessary they will need a base from which to operate. More important a recognised storage area will be required for their rigging equipment.

This area should be dry and racking should be provided so that equipment can be stored off the floor and readily accessible both for use and for inspection and cleaning. It is important that the job of inspection of rigging equipment be the first priority responsibility of one man suitably trained for the job. The consequences of lifting gear failure in use can be extremely serious both in terms of property loss as well as life and limb.

A register of all items of lifting equipment must be

kept and all the items should be identifiable against the register. A regular schedule for inspection of all equipment should be operated and unserviceable items withdrawn from use for repair or replacement. Such a register and inspection routine are mandatory in the U.K. and other countries. The statutory regulations in these countries form a useful reference for instituting a procedure where no legislation exists.

It is often useful to include scaffolding and access equipment within the responsibility of this group. Many suitable systems of quick erect scaffolding are now available besides the more conventional tube and clip system. Whichever system suits the situation best, adequate storage space will be required and inspection of the equipment whenever it is returned from a job. Together with the scaffolding framework, timbers will be required to form walkways and toe boards on the finished structure and also ladders for access. As many maintenance or repair jobs are necessary in confined or inaccessible places, scaffolding timbers and even ladders get cut up into short lengths and are mutilated in other ways. Often through handling operations with heavy equipment boards might be split or cracked and ladders damaged. Spillage of oil or chemicals similarly can have a deleterious effect on the timber. For all these reasons it is also essential to carry out regular inspection of equipment in use.

The provision of a central storage area with a responsible person in charge makes it possible for these inspections to be carried out. It also provides for control of the inventory of all lifting or access equipment. Missing items can be noted and searches can be initiated. With

structures in use over a long period, the inspections must be carried out in situ at the predetermined regular intervals.

6.1.2.9. Transport Workshop

An essential feature of any maintenance and repair organisation is transport. In its most simple form it may consist of perhaps a sack truck or handcart. The possibilities range wide from this starting point depending on the size of the organisation and the work to be done.

The purposes for which the transport or mobile equipment may be used are simpler to enumerate than the variety of vehicles available to fill the need. The main aim in selecting the vehicle is maximum flexibility of purpose so as to ensure maximum utilisation with minimum capital expenditure.

For example, personnel carrying, carriage of small items, carriage of heavy equipment and say snow clearing could require the provision of a mini bus, a van, a lorry and a tractor. All the same duties could be carried out by use of a utility vehicle suitable for towing and provided with power take off, together with a suitable trailer.

Besides the duties mentioned in the foregoing paragraph, mobile equipment may be required for lifting, access, earthmoving, bulk material transport and material handling.

In addition to the maintenance and repair organisation, other functions within the enterprise will have transport needs. These will include personnel carriers, mechanical handling equipment both in plant and in the warehouse, fire tenders, factory internal goods transport and possibly even an external goods fleet.

If the factory is served by rail, shunting locomotives

for the factory sidings may be necessary.

The first aim with regard to maintenance of factory transport should be to contract out as much as possible to specialists in the field. Owing to local circumstances this may not always be possible. Even when it is possible, routine maintenance servicing jobs are better carried out on site and some facility is necessary for immediate repairs when time cannot readily be made available to fit the contractors programme.

The transport maintenance workshop then should be provided with facilities in line with the needs. Essentials will include the general engineering accessories common to all maintenance workshops. That is, grinding and drilling machines, power tool facilities, lifting facilities and so on.

In addition at least one inspection pit will be necessary, provided with a suitable means of covering when not in use. Other features should include a ready means of removing road dirt and accumulated grease, a degreasing tank for disassembled parts, well ventilated battery charging facilities and distilled water supplies, tyre changing and testing equipment, high pressure greasing equipment, spark plug cleaning and testing equipment and wheel alignment checking gear.

Oxy-acetylene welding equipment should be available for bodywork repairs and extension handlamps suitably protected against damage and short circuit. The hazards of using both these items and power tools in the vicinity of gasoline should be clearly understood by all concerned and adequate precautions taken. The inspection pit is an extremely hazardous area in this respect. Steaming facilities for gas freeing of fuel tanks before any

repairs are undertaken should be provided outside the workshop itself. Another serious hazard to be guarded against is the carbon monoxide generated when running vehicle engines. Within the workshop, engine operation should be prohibited except for driving in and out when the doors should be open.

If it is necessary to test run engines in the workshop, an exhaust extract system should be provided which can be connected to the vehicle exhaust and discharged outside the workshop.

Finally some means of collecting and disposing of waste sump oil is required. Depending on the quantities involved it is possible, with a suitably designed boiler to make use of it for space heating purposes.

Storage facilities will be required for spare parts, engineering goods and supplies and for tyres, oils and greases. Generally a good deal of both covered and open parking areas are usually found necessary. This would be for vehicles awaiting spares and for those whose size or shape make it difficult to fit into the workshop when requiring servicing or maintenance.

6.1.2.10. "On Site" Facilities

Much "on site" work will be of a minor nature. This minor work will include true maintenance work, lubrication adjustment of wearing parts and so on. In the repair category, the minor work will be that which can be carried out on the plant with a minimum of facilities.

Facilities in these circumstances will only be what the maintenance and repair crew can conveniently carry with them.

will need "on site" facilities for removal of the plant from the operating situation.

Major plant shutdown work also generally involves extensive "on site" work. Because the plant is out of service, working conditions are favourable and with major items of plant removal to a workshop is expensive.

Finally, work on certain major items of plant, for example, boilers, would always be "on site" work.

Some facilities for major "on site" work will be installed in the plant location. Other facilities will be transportable from one operating unit to another.

Fixed equipment will include lifting beams. Depending on the frequency of use they may be fitted with lifting trolleys, blocks or hoists. Other fixed facilities might include pipework to supply compressed air, water, gas or steam or to vent equipment or provide drainage.

Provision of such facilities would depend on the frequency of the work and the possible savings.

Portable facilities would include portable tools as described in the workshop discussion. Portable benches with vices and tool box trolleys can be provided. Scaffolding, ladders, stepladders and possibly hydraulic access equipment will be necessary. Lifting equipment might include jacks, winches, hoists and lifting blocks. The workshop equipment lists in Appendix ... details such equipment.

A mobile materials and tools stores which can be parked at the plant will be useful in reducing stores trips on

6.2. Office Facilities

The office facilities required by the maintenance and repair organisation will depend both on the size and type of organisation which is set up. The office facilities required by supervisors in the workshops have already been mentioned.

The remainder of the maintenance staff should be housed together wherever this is possible. The siting of the central office facilities probably is most suitable adjacent to the central workshops complex. By siting here, communication between the major part of the organisation will be simplified. The staff functions which are to be housed in the central office will include the senior management, the maintenance improvement group and the planning group, the secretariat and maintenance files.

By grouping in one building, the identity of the organisation as a single team with a common aim can be best preserved. Secretarial facilities can be shared to ensure maximum utilisation and duplication of files can be avoided. An "open plan" office system can be adopted with value for both the maintenance improvement and planning groups. By this means maximum contact between the members of the teams can be encouraged to avoid duplication of effort. The planning group will be encouraging frequent and regular contact with the supervision and workforce. For this reason it should be readily available from the workshops, without the need for people to pass through other sections. In addition, soundproofing between this section and the rest of the office should be adequate.

Apart from sufficient desks and filing cabinets the office facilities should include storage for drawings, table space for studying them in each office area, and sufficient drawing boards and equipment to meet the casual needs of the groups.

If facilities are not available elsewhere in the enterprise and are not locally available it may be necessary to install facilities for dyeline reproduction of drawings and reproduction of documents.

Within the planning group, wall area will be necessary for display of charts and programmes. Great use is made in some planning offices of wall displays of maintenance schedules and programmes. Use of such things while looking most impressive are of questionable value unless they are carefully designed to achieve a particular objective. They are only justifiable if they carry out a necessary function which cannot be achieved better in any other way. All too often they are merely toys which are the pride and joy and sole preoccupation of one man and duplicate a job which is being done initially on paper. A document which can be reproduced and distributed for ready

reference is often far more use.

Planners generally frequently need to make sketches. Provision of sketch pads printed with a squared or isometric pattern can be very useful.

Another useful tool is a polaroid camera which can often be used to eliminate the need of sketching altogether.

Little in the way of special facilities will be necessary elsewhere in the central office apart from perhaps a desk calculator or two in the maintenance improvement section.

The subject of communications can perhaps be briefly discussed in this section. Telephonic communication between the centre and the various branches of the organisation and with the operations they serve will be necessary. A recording device to receive non-urgent messages can be a useful asset for use of work requests and instructions. External telephone links will be required also, particularly for the maintenance improvement group and senior management.

A radio link between the planning group or the transport supervisor and the maintenance transport fleet can pay dividends on a large factory site. Similarly a personnel radio call system used in conjunction with the internal telephone system can greatly reduce the frustrations of difficulties in contacting key personnel quickly. It also frees them from the discipline of leaving frequent clues to their likely future location.

These systems however do represent a fairly high investment and require fairly sophisticated maintenance techniques in themselves if they are to remain serviceable.

7. MAINTENANCE AND REPAIR TECHNIQUES & POLICY

The policy of any maintenance and repair organisation must be to aim to maintain operational plant at the required level of availability at the lowest cost. This is a very wide ranging statement and is of little value in determining action to be taken in any given set of circumstances

which may arise during a day's work.

It is necessary, therefore, to determine certain lines of action or strategy to be applied as general guides in everyday decision making, which in themselves will guide the organisation towards the general objective.

7.1. Maintenance, Repair and Replacement

Generally with any item of plant it is possible to adopt one of three courses of action or a blend of the three, to ensure availability as required. Whichever policy is to be used with a particular type or item of plant must be determined in relation to a number of factors.

7.1.1. Maintenance

It is possible to apply maintenance to almost every item of plant in the form of routine servicing, that is lubrication, adjustment and so on. However, in this context we are considering the broader meaning of the term. With major items of plant which have a critical role in the production sequence a scheduled maintenance approach is necessary. Other factors which qualify plant for scheduled maintenance treatment will include:-

7.1.1.1. Items whose failure in service could lead to extensive damage and property loss. For example, high speed rotating machinery such as steam turbines, vessels operating under high pressure or lifting equipment.

7.1.1.2. Items whose failure in service could lead to serious hazard to life and limb apart from those hazards in 7.1.1.1 For example, critical process control instruments, pressure relieving devices, interlock systems, fire detection or control systems.

7.1.1.3. Items in continuous process lines whose failure in service can result in serious process interruption.

7.1.1.4. Items whose complete failure can present a major repair or replacement problem. For example items for which a complete replacement spare cannot be justified as cost and delivery times are excessive. This could include turbines, generating sets, compressors, blowers or any major item of plant.

Application of scheduled maintenance routines to anything other than such items, apart from servicing can lead to excessive maintenance and repair costs. Scheduled maintenance tends to be expensive because of the organisation necessary to ensure its effective application and because, by definition, plant is overhauled before its working life is fully exploited.

7.1.2. Repair and Replacement

The remaining work will be carried out on a breakdown basis. This is not to say that plant should be allowed to cease work completely before attention is given to it. Reporting of malfunctioning of plant should be encouraged from the process operators and supervision. Additionally, the maintenance and repair supervision should devote part of their attention to inspection of operating plant during their visits to their areas of responsibility on the factory. When malfunctioning is detected of sufficient seriousness to affect production, action to correct the situation should be instituted. With practice and familiarity with the plant, often corrective action can be determined by the responsible maintenance supervision.

7.1.2.1. Determination of Corrective Action

For the sake of completeness the sequence of factors which will determine the corrective action are listed as follows:-

1) An estimate of the seriousness of the malfunction and

the probable progress of further deterioration.

2) The method to be adopted to return the plant to operating efficiency.

3) The effect of shutting down the plant on production. Whether an immediate shutdown is necessary or if a convenient time can be arranged in the near future.

4) The availability of manpower and repair facilities and spares and the extent of preparations necessary.

5) The relative importance of the plant under consideration compared to other plant undergoing or requiring attention.

Whatsoever the importance of the plant or the magnitude of the problem, these questions must be answered. The level of responsibility at which the answers are given and the decision made will vary with the magnitude of the implications of the problem. However, training and development of the maintenance and repair staff should be aimed at encouraging the major part of this work to be carried out at the first level of supervision. This level should however be able to differentiate clearly between decisions within their scope and those with sufficiently far reaching implications to require reference to higher authority. Understanding is best reached on these matters if some sort of regular but informal reporting system is encouraged. The more senior level of management is then able to recognise where decisions have been passed to too high a level or otherwise and can encourage acceptance of the desirable level of responsibility by their subordinates.

Correct operation in this sphere is vital if each level of management is to perform its proper function.

A most important factor which is all too often neglected in making these sort of decisions at all levels is the effect on production.

Because the maintenance and repair staff are specialists in their way, their main concerns tend to revolve around condition of equipment and engineering standards of performance of work. All too easily they can forget their prime function is to provide the plant in a suitable condition for production when it is needed.

Decisions on when to do a job and what standards of performance are necessary should always be guided primarily by production requirements. That is, the effect of their decision on production either in the short or long term. The person making the decision therefore has the responsibility of consulting the appropriate level of production management in the process of arriving at his conclusions.

7.1.2.2. <u>Alternative actions</u>

Of the questions to be answered listed previously the one relating to the method to be adopted is the one which exercises the professional competance of the maintenance and repair man to the fullest degree. In fact, the answer to this question is one which must have been answered in advance of any failure.

It is the responsibility of the maintenance and repair organisation to examine each item of plant to determine the possible causes of ultimate failure. From this, decisions on whether to attempt to repair the plant when it fails or to replace it should be made. Possible actions which may be taken could include:

Scrap the item and instal a new one with a spare to be held in stock

Dismantle the item and replace those parts of it which have failed with spares to be held in stock and then reinstall.

Dismantle the item and repair those parts of it which have failed and then reinstall.

Remove the item and install a replacement which is to be held in stock, then overhaul the failed item using either of the two previous methods. The overhauled item then to be held in stock against future failure.

Arrange for a duplicate item of plant to be installed in the process line which can readily be brought into service so that the failed item can be removed for overhaul.

Preplanning of this form is one of the strategys referred to at the start of this section. Commenting on each possibility separately:

7.1.2.2.1. Items should be scrapped and replaced where the total cost of repair exceeds the cost of replacement. In estimating the total cost of repair, the cost of production loss, the cost of stocking or preparing spare parts and the need to maintain facilities or specialist skills for carrying out the repairs should be considered in addition to the direct material and labour cost of the work. This should be balanced against the cost of stocking the spare item of plant, the anticipated replacement frequency and availability of replacements.

7.1.2.2.2. The effect of the non-availability of the plant during repair will determine whether time can be allowed for dismantling for parts replacement or repair. Whether to stock spares, make spare, or repair worn parts will again depend on the cost of stocking, availability of spares, cost of making or repairing items, balanced against the time available and so on.

7.1.2.2.3. Replacement with a spare is a compromise between the foregoing. It is a useful way of dealing economically with fairly critical items of plant. By reducing the urgent part of the work to a minimum it permits better

planning of use of repair facilities. This system can be used to excellent effect when there are a number of identical items of plant in use. The ability to use this system of maintenance economically is one of the strongest arguments in favour of standardisation on the smallest possible range of propriety items of plant in use on the factory.

7.1.2.2.4. Installation of standby spare items of plant can only be justified by critical production requirements. For instance, in continuous production units where failure of the item concerned will immediately cause shutdown of the unit and where the anticipated operational life of the unit is less than the required period of operation of the total production unit.

If an installed spare must be included in the unit, precautions must be taken to ensure that when required it is capable of operating effectively for its normal anticipated life span. It is a fact of life that operations personnel will use the item of plant which gives them least trouble. As soon as the line item shows any sign of wear, the operator will use the standby in preference. He will continue to use whichever is the better of the two items until one of them fails completely. At this stage it is not unusual to discover that the standby spare is in little better condition.

Control of the situation is therefore necessary. Use of the standby must be prohibited until the line unit reaches an agreed condition, except for specified periods of test running to check its condition and retain it in working order. Changeover to the standby must be accompanied by a reporting system which ensures maintenance attention to the line unit at the earliest possible time.

Human nature being what it is, physical means of restrict

use of the standby is preferable to rules and instructions. If changeover time permits, installation of blanks in pipelines or perhaps the need to remove a section of pipework from the line unit to couple up the standby can be useful devices. Locking out of electrical supplies, together with a procedure for obtaining the key is another means. This tends to be less effective due to the ease with which locks can be opened, or damaged.

7.1.3. Whichever strategy is adopted with each type of plant initially it will be necessary to review the procedure from time to time. Initial estimates of failure frequency will need modification in the light of experience. Causes of failure will vary from what was anticipated and spare part requirements also. Possibly the most difficult factor to determine is the relationship the various items of plant bear to production efficiency. The production staff will tend to overestimate the effect of failure on production and will underestimate their ability to continue production in the absence of any item of plant. Experience will eventually show the true situation, usually as a result of a premature failure or other unexpected circumstance. The initiative in determing these factors accurately must come from the maintenance and repair organisation if excessive costs due to high spare stock levels, unnecessary emergency and overtime work, or over maintainin of plant is to be avoided. If a maintenance and repair organisation operates without complaints from production or service departments, this is a sure sign that the organisation is overstaffed and is costing more

difficulties and complaints there will be no searching for better ways and means of ensuring an efficient service.

8. SAFETY AND WELFARE

It is well recognised that safety at work is a matter for concern simply from an economic standpoint apart from any human consideration. Because of the nature of maintenance and repair work and the tools which are used, maintenance men are probably exposed to more accident risk than any other group in a factory. Also, they have most influence on the safety of others through their responsibility to ensure plant is safe to operate. Every man in the maintenance and repair organisation must be aware of this responsibility for himself and others. He must be trained to work safely, not to take shortcuts, to be sure of the consequences of his actions, to keep his workplace tidy and his tools in good safe condition.
Safety must always be uppermost in his mind so that his reaction to a job is not "how can I do this job" but "how can I do this job safely".
Hazards cannot be eliminated from maintenance and repair work. However, accidents can be eliminated by recognition of the hazards and selection of the most practical means of controlling them.
To obtain a consistent approach to safe working by maintenance and repair men is a long and difficult process. The process will be impossible however if the management does not show by action as well as words that they too are committed to such an approach. Men will not keep their workplaces tidy if their workplace is tumbledown and uncared for.
Guidance is necessary to establish means of tackling particularly hazardous operations and facilities must be supplied to match the instructions or guidance given. For example procedures should be established to cover the following:-

Guarding of moving machinery

Isolation of machinery for maintenance or repair

Access to and safe working on roofs

Opening of pipelines.

Provision of adequate welfare facilities is another means of demonstrating the organisations concern for the well being of its employees. Such facilities will include adequate toilet and washing facilities, facilities for the storage and if necessary, drying of clothing and a means of storing food and a suitable place for eating it.

Dependent on the industry concerned there will be specific problems with regard to industrial diseases. For example, numerous hazards associated with toxicity in the chemical industry, dust and pneumocosis problems in many industries and skin cancers from exposure to mineral oils in engineering industries. Each of these problems require their own precautions in the way of instruction, procedure, washing facilities and provision of protective equipment. Attention to these problems by the organisation will set the minimum standard for employee welfare on which to build a healthy approach to safe working.

9. ADMINISTRATION

As the size of an organisation increases so it becomes necessary to establish rules or procedure for its operation. The aim should be to keep such rules and procedures to the absolute minimum necessary to permit effective operation of the organisation. Every procedure or rule must be established on the basis of a recognised need and must have a specific objective. Some rules will be mandatory, generally for safety or property protection purposes or maybe for financial reasons. For example, no smoking in the fuel store, or levels of authorisation of expenditure. Non mandatory procedures and rules will generally apply to operation of the organisation to avoid the possibility of duplication of effort. The aim with these will be to ensure that others concerned are consulted when particular actions are being taken. The essential need for rules of this kind is to ensure that they leave the maximum scope for the exercise

For the maintenance and repair organisations procedures are desirable apart from those previously mentioned under safety and those necessary to specify the functions of the various groups forming the organisation. These will include procedures governing

Work requests

Allocation and reporting of costs

Budgetting and budget control

Discussing each in turn:

9.1. Work requests

A properly organised written work request system can serve three purposes.

First, provide a visual record of work backlog and supply the basis for planning maintenance work.

Secondly, provide information for use in determining where maintenance improvement effort must be applied.

Thirdly, provide the basis for a maintenance costing system.

There are many ways of organising a work request system but the basic essentials of all of them are similar. Details of a system in current use is included in Appendix .....VII.

A workable work request system must comprise a written record of the work requested. Without this, completion of maintenance and repair work depends on the memory of the supervision. Excellent as these may be, inevitably essential work will be forgotten sooner or later, with serious consequences in terms of production loss, property damage and maybe even injury or worse.

The written work request must be arranged for minimum effort and time to compile and will contain certain key information as follows:-

Location of job

Item of plant concerned

Description of defect or name of person to contact for details

An indication of urgency or time by which completion

Date work request was placed

Name of initiator of work request

Subsequently the work request must be given a reference number for identity purposes.

A carefully designed work request form can ensure that the initiator is reminded of these needs when placing his request.

9.2. Allocation and reporting of costs

Correct allocation and reporting of maintenance and repair costs is necessary with any enterprise producing more than a single product, if the true production cost of each product is to be established. Apart from this objective, the maintenance and repair organisation itself has need of a breakdown of their costs. This cost breakdown provides the necessary information to enable future expenditure budgets to be drawn up. They also provide information for cost control by indicating areas of high expenditure or trends in expenditure in any particular area. Further applications include use of the information provided to form the basis of estimating costs of work so that decisions on repair or replacement or economic feasibility of proposed modifications can be made. The costs also form the major source of information for the maintenance improvement group.

As with most things compromise is necessary in determing the form that the cost reporting system will take. The compromise will lie between what information is desirable and the effort necessary to allocate and report it. Allocation of costs to the correct cost centre has to be done at source. The supervisor is the only person who is aware of exactly which jobs his men are occupied on, for how long and what materials they use during the course of it. He of necessity therefore must spend some of his time in reporting this information to the accounts department.

The more information he is required to report the more time he will

For the purposes of product costing it is obviously necessary to separate charges on this basis. If there are a number of plants producing the same product, differentiation between these plants is useful to determine which of them is the most efficient.

The sort of information most useful to the maintenance and repair organisation is the cost of maintaining particular items of plant or types of plant. For instance, cost centres could include: pipework, pumps, heat exchangers, centrifuges etc.

In some plants particularly significant items of equipment may be worthy of special attention, perhaps a waste heat boiler or an autoclave or a packaging machine.

A typical cost reporting system would consist of a series of numbers each representing some aspect against which costs are required to be collected.

For instance:

2 digits	-	represent the plant or product
1 digit	-	represents the class of work, for example, routine, shutdown, emergency, expense associated with capital work or work to assist operations.
1 digit	-	represents the group undertaking the work: area or centralised force, electricians, instrument mechanics, civil trades.
2 digits	-	represents the type or item of plant on which the work is carried out.

as an example:

01	-	could be one of up to 99 product cost centres.
2	-	could be routine work
3	-	could be work carried out by the area work force

The time spent and any materials used would be reported against 012304. The variations that can be applied to a basic system of this sort are limitless and can be applied to isolate whichever source of expenditure is required. The extent and detail to which it can be applied must of course depend on what detail it is practical to expect supervision to supply as input.

If further information is required when investigating causes of maintenance costs, copies of work requests can be retained for future reference. Another system is exampled in appendix VIII

9.3. Budgetting and Budget Control

In order that reliable forecasting of product costs can be made it is necessary for the maintenance and repair organisation to forecast the future cost of maintenance. The budget thus produced will then serve as the cost objective for the period concerned. The budget also serves as a yardstick against which to measure the performance of the organisation. By its use, abnormal occurrances or trends of cost can be observed and corrective actions determined.

It will be realised that it is not possible to forecast accurately, exactly what the future will bring, but it is possible to foresee the likely trend of the immediate future. By doing so it is possible to forecast future costs assuming nothing extraordinary will occur. When such occurrances do inevitably happen, they can be recognised and their impact can be isolated. Preparation of budgets is an exercise that improves with practice. Budget preparation must initially be based on previous experience. The more often budgets have been prepared previously and compared with subsequent performance, the more apparent will normal trends become.

A typical budgetting exercise might be organised as follows:

The prelude to budget preparation would be the formal presentation of costs incurred over the immediate past. As budgets of necessity must be prepared in advance of the period concerned, the complete costs forthe current period will not be available. The performance

against budget for the previous period then will be the best comparison available. Thus we would have

Budget for previous period

Actual costs for previous period

Budget for current period

Actual costs to date for current period

An estimate can now be made of the likely outcome of actual costs for the current period.

This information then represents the best guide to future performance. Next it is necessary to isolate major cost items from the actual performances. These should fall into two categories, those which were anticipated and those which were not. Further, items which were anticipated by the budget which did not occur should also be identified.

Once this sort of information has been isolated one is left with a background of cost which is made up of small cost jobs. These generally will be routine maintenance or adjustments and so on. One can assume, providing no extraordinary change in plant is anticipated, that these costs will continue to be generated at the same rate.

Inspection of all the other major items is now required to determine the likelihood of a repetition in the next budget period. Inspection of these and indeed the routine or background costs must be made in the light of information available from production on the budgetted production rates for the forthcoming period, any plant extensions or modifications proposed and any maintenance improvement work anticipated. Having determined the likely work load in terms of current costs it is then necessary to vary these with reference to trends of material and wages costs.

By this means the budget for the forthcoming period can be built up.

However, before it is finalised it is often useful to make a few checks. For instance, over a few years, ratios between labour and

materials costs can be established and also the normal relationship between contract maintenance costs and costs of maintenance by company employees. A check between these ratios and the proposed budget can avoid the possibility of budgetting for far more work than the maintenance team could possibly handle, or alternatively predicting costs which are lower than will be generated simply by continuing to employ the current workforce.

Dependent on the circumstances, other factors may have to be borne in mind. For instance, anticipated overtime levels and premium payments involved. Also the amount of non-maintenance work to be carried out by the workforce. This could be minor capital work or plant modifications or improvements.

Obviously, the more comprehensive the cost reporting system, the simpler identification of extraordinary costs will be and the more realistic the budget forecast. Another important point to remember is the need to fully document the considerations affecting the build up of the current budget. Without these reasons, it will not be possible to make much sense of it in twelve months time when the next budgetting exercise is due.

Good documentation is also necessary if the budget is to be of use during the budgetted period. By organisation of the budget into monthly expenditure, control of maintenance expenditure can be exercised throughout the year. As far as possible the monthly predictions should be realistic. Anticipated major expenditures should be included in the month's budget they are expected to occur, if use of the budgets for control is to be useful.
If the timing of a job is not exactly predictable, the anticipated cost can be extracted from the annual figure and injected into the budget for the month at the time it occurs.

10. WORK CONTROL AND WORK MEASUREMENT

Many techniques exist which can be used to determine the efficiency of the workforce. They are generally based on the principle of determining the work content contained in the tasks to be carried out and comparing the actual performance of the workforce with them.

These techniques in themselves do not provide any control of work. Control of the maintenance work will always remain the prime function of the maintenance supervision. The techniques of work measurement however do provide the necessary information for the supervision to determine how many men they need, and whether efficiency of work is at an acceptable level.

It is suggested that initially the less sophisticated techniques are all that are required. The more specific and sophisticated techniques are costly to apply and require a good deal of understanding by supervision and the workforce if the cost of installation is to be recovered by increased efficiency.

Briefly the more generally used techniques are outlined together with some idea of where and how they can be utilised. However, most of the techniques cannot be fully developed in a paper of this scope. Much has been written on these subjects and expert guidance is available if it is decided to proceed along any particular line.

10.1 Work Study

While work study in itself is not a technique for measuring work it is the background to most techniques. In addition it is an invaluable tool in all aspects of maintenance and repair work, ranging through the administration, supervisory and work execution fields. Certainly all the Maintenance Improvement Group staff should be familiar with work study techniques and also the Planning Group staff. Preferably all the supervisory staff should have a working knowledge of the subject, with perhaps one member of the staff who

is a trained work study practitioner.

Use of the work study questioning procedure by maintenance supervision when deciding how to organise their work, can result in well organised working procedures.

Major overhauls or repair procedures of critical items of equipment are in the province of the work study engineer.

Organisation of the workforce, administrative procedures, costing systems, layout of workshops and types of tools and equipment are also suitable subjects for his trained approach.

10.2 Estimating

The most basic form of work measurement is contained in the various practices of estimating.

In its simplest form estimating will consist of deciding how long a job may take and how many men are required, based on the estimators previous experience.

The procedure can be refined by collecting the knowledge of experienced men, by comparing actual performances against estimates and by collecting simple data on the quantity of work contained in jobs whose performance time is known. For example, simple factors can be determined for the installation of pipework based on the length and bore of pipe, with modifying factors depending on accessibility of the piperun, number of bends and so on.

10.3 Work Sampling

Work sampling is a useful procedure for comparing performance from time to time, to determine trends of performance and activity. For instance, measurements before and after a change in organisation can indicate whether the effects are beneficial or not.

The technique is based on statistical probability and consists of sampling a number of preselected factors on a random basis. The number of samples required can be determined to give the required probability of error.

The technique is simple and requires a minimum of instruction to apply. The results it produces, however, are only as specific

as the factors selected. The procedure is better used to compare change in the factors over a period, rather than to quantify the factors themselves.

A typical application of the technique was its use to determine change in workforce activity over a number of years.

The factors selected for study consisted of three activities, Working, Travelling and Standing. These factors were then defined in some detail for the observers so that the possibility of different interpretations of activity by different observers could be minimised. In this way successive surveys could confidently be compared.

As a simple example, a rigger standing waiting for a load suspended from a crane to come to him, might be classified "Working" by one observer and "Standing" by another. A predetermined approach to these sort of situations is necessary.

The method of observing must also be defined. For example, an observer sampling continuously as he walks will get different results to one who proceeds to a particular position, say the centre of a workshop, before sampling. In the latter case for instance, the knowledge of his presence will result in change of activity of the men under observation.

An essential factor in any of these techniques which involve observation of the workforce is that of participation.

The workforce must be fully aware in advance of what is being undertaken, and what its purpose is. If this is not attended to, any results obtained will be questionable. It is a simple matter for a worker to spoil the results by reacting to the presence of the observer with a spurt of activity, or by complete inactivity. At the very worst, application of observation techniques without workforce participation will result in poor industrial relations and even strike action.

10.4 Analytical and Synthetic Work Measurement

These descriptions are applied to the more sophisticated methods

referred to earlier. In effect they are an extension of the techniques of estimating combined with work study.

In essence they involve the reduction of any job to minute detail, the determination of the time required to perform each element and reassembly of the elements, together with suitable allowances, to give performance times for complete jobs.

Again much information is available from consultants who specialise in variations on the basic idea and who have already collected or produced data for building up, or synthesising, job times.

Introduction of any system of this sort must only be undertaken after a careful study of the maintenance and repair situation to determine the needs for improvement. The technique to be applied must also be carefully studied and its fitness for the results required determined.

Again full information must be made available to the workforce who must themselves be convinced of the need for the system, and see some benefit in it for themselves.

Often these techniques are applied as the basis of an incentive scheme for payment of the workforce.

Neglect of any of the aspects mentioned can result in complete negation of any benefits which might be expected from the project. Poor results recorded in a number of organisations have ranged from complete rejection of the system after a period, or continuation of the system, operated at shop floor level purely with the purpose of guaranteeing an acceptable level of take home pay.

In either case the system has merely become an expensive exercise. Poor application of such schemes can and usually are accompanied by deterioration of industrial relations based on lack of confidence in management. If the scheme is installed as the basis of incentives, it is very difficult to get rid of, if it doesn't work. At best it would involve an expensive "buying out" situation.

The author is convinced that it is necessary first to explore fully the less sophisticated methods of improving efficiency. When

efficiency can be improved no further by these means, then it is time to explore the more advanced ones. By that time both the staff and the workforce themselves will have advanced to the stage where they accept and understand the procedures.

11. Conclusion

The foregoing discussion, together with its bibliography, is intended to direct the reader towards an understanding of the factors which must be considered in the setting up and operation of a maintenance and repair organisation in any industrial enterprise.

The factors which will affect selection of one form of organisation or another, or adoption of one technique or another are indicated.

It will be apparent from the discussion that there is no single solution to the problems of maintenance and repair. Any organisation is shaped by the local circumstances and the job it is called upon to do.

It is hoped that the information provided will be of assistance in setting up organisations which meet initial plant needs. Alternatively, where organisations already exist, perhaps the discussion will aid in planning future development or strengthening such organisations.

APPENDIX 1

T E R M I N O L O G Y

Plant - Refers to all mobile or fixed machinery, plowears, switchgear, cabling etc. which forms a part of any production or service facility, or any group of items of equipment which comprises a production or service facility.

Maintenance - Is used as a general term to describe overall activities of a maintenance and repair organisation. When used in a specific sense it refers to the servicing of plant which is in operable condition, to ensure continued operation at the required level of efficiency. This would include lubrication, cleaning, adjustments to clearances, glands etc., resetting of cutting edges and replacement of parts or units which, by design, wear or are consumed in operation i.e. grindstones, cutting fluid, filter elements and so on.

Repair - Refers to the operations required to return plant which has ceased to function effectively back to operating efficiency.

Replacement - Refers to substitution of an item of plant with a new item of similar design in preference to repair.

Unit replacement - Refers to the replacing of defective parts of an item of plant with new parts, in preference to repair of the defective items.

Installed spares - Refers to the installation of additional items of plant not required for normal production which can be put into service immediately another becomes

non-operational. These items are installed in the production flowline and do not require more than switching on power, or services, by production personnel, to put them into service.

Non-installed spares - Refers to complete items of plant, replicating specific items of production plant. These may be held in a storage area or installed adjacent to the production flowline. These items require installation work by other than production people before they can be made operational. Normally the installation will be arranged for the work to be minimal. Nevertheless, an essential feature is the need for a service from other than production personnel.

Planned maintenance - Is a general term that refers to any work carried out to maintain or repair plant which has been pre-arranged.

Preventative maintenance - Refers to work carried out on plant with the objective of forestalling equipment breakdown or deterioration. Such work may or may not be planned.

Scheduled maintenance - Refers to any work carried out on plant on a regular basis in accordance with a pre-arranged programme.

Shutdown maintenance - Refers to any work carried out on major items of plant or sections of production plant, on a planned basis which requires the complete shutdown of the item or section of the plant.

Breakdown maintenance - Refers to work on plant which is not initiated until after it has ceased to function. Breakdown maintenance may be planned, to the extent that a contingency action in the event of breakdown has been prepared.

Emergency maintenance - Refers to urgent maintenance that must be done, because of the relationship of the failed item to the production, situation or to safety requirements, must be started immediately. Such work will, by definition, take priority over most work already in hand.

Artisan - Is a general term referring to personnel who are engaged in physical or manual operations. For example, craftsmen, tradesmen, operatives.

Staff - Is a general term referring to personnel engaged in administrative, supervisory, technical or managerial operations. For example, clerks, foremen, draughtsmen, engineering specialists, managers.

Supervisor - Is a general term referring to anyone engaged in directly overseeing the work of others to ensure performance to the required standard. This term is used in preference to the term foreman.

Manager - Is a general term referring to anyone engaged in organisation and control of the work of others. In these terms a supervisor is also a manager. However, the term supervisor is reserved for the first line of management, where the control is of persons who themselves have no management or

Line Function - A line function is defined as one in the direct chain of command controlling the efforts of the workforce. Line responsibilities are then responsibilities for control of the workforce and execution of work.

APPENDIX 11 [illegible]

[illegible]

I. [illegible]

To define the methods to be used in requesting the services of Maintenance Improvement Group and the responsibilities of the various persons involved.

II. [illegible]

It is the intention of Management that Maintenance Engineering problems should be handled by a Group free from line responsibilities. It i considered that this service should be freely available to all, via a formal request system designed to ensure:-

(a) that a clear statement of the problem and objective is received by the Maintenance Improvement Group.

(b) that appropriate line supervision are kept informed of requests emanating from other departments.

(c) that all requests irrespective of origin are approved by appropriate line supervision at initiation stage.

(d) that effective communications and relationships are maintained between staff and line organisations.

(e) that the improvement programme is effectively organised and controlled.

[illegible]

The service of the Maintenance Improvement Group should be used for the solution of engineering problems associated with excessive maintenance cost or mechanical downtime.

IV. [illegible]

Initiation of Service Request

Any member of the Supervisory staff may submit a problem to the Maintenance Improvement Group. The request should be presented on a Service Request Form (copy attached).

Requests raised within Maintenance Department

The request form will be routed through the appropriate Maintenance Superintendent and the General Superintendent of Maintenance for signature approval and onward transmittal to the Superintendent of the Maintenance Improvement Group.

Requests raised outside Maintenance Department

The request form will be routed through the General Superintendent of the initiating department, the Superintendent of Area Maintenance and the General Superintendent of Maintenance for signature, approval and onward transmittal to the Superintendent of the Maintenance Improvement Group.

Receipt of each authorised request will be acknowledged by the Superintendent of the Maintenance Improvement Group and a rough estimate given of the date that the investigation will be put in hand. The request will be allocated a request number and registered by the Maintenance Improvement Group secretarial staff.

Preparation of Service Request

The Service Request will include the following information.

Job Title

The job title should provide a brief reference to the equipment or system needing attention and a concise description of the nature of the problem itself, e.g. Moulding Pump - Recommendations for improved bearing life, or Building Maintenance - Evaluation of roofing materials.

Statement of Problem and Objective

This should provide a clear definition of the problem including scope of study and a review of the objectives to be gained by its solution.

Estimated Savings or other Benefits

This section should provide an indication of the estimated gross savings to be realised or any other benefits which may be derived from the solution of the problem. Where practicable, this information is to be provided by the originator, but where not, it will be provided by the staff engineer assigned to the job.

Suggested Approach, References, etc.

This should include any ideas the originator or other persons involved may have, for attacking the problem. References to background information or to files or publications which may be helpful, should also be listed to provide as comprehensive a picture of the problem as possible.

Other Information

The department number, location, name of initiator and date of initiation, should be entered by the originator in the spaces provided.

Manpower Requirements, etc.

This portion of the form will be completed by the Maintenance Improvement Group. If other staff or line groups are involved, the scope of their participation is to be defined under special instructions. The relative priority of the job must also be determined and an appropriate statement included. The Superintendent of the Maintenance Improvement Group will insert the estimated completion date of the project.

Initiation of Staff Investigation

When the investigation is put in hand, the staff engineer assigned to the job will, if necessary, re-draft the Service Request and submit it to the Superintendent of the Maintenance Improvement Group.

On approval, the request will be passed to the Maintenance Improvement Group Secretarial Staff who will prepare the required number of copies of the request for distribution. Issue of these copies will indicate that work has started on the investigation.

Distribution

All Service Request forms will have the following distribution:-

Works Manager/General Superintendent, Maintenance.
General Superintendent, Project Group.
General Superintendent of Production or other Group concerned.
Superintendent of Maintenance Group concerned.
Originator of request.
Superintendent of Maintenance Improvement Group/Staff Engineer concerned.
Foreman of Maintenance Group concerned.

Reports

A Monthly Report in summary form will be issued covering all major activities of the Maintenance Improvement Group. In addition, if a request involves a lengthy study, then a Progress Report will be issued to all recipients of the Service Request at significant phases during the investigation or at six monthly intervals where there is little progress to report.

The progress report will show the form the study is taking together with an outline of future work and any new ideas which are considered to be worth following up.

Recommendations

Recommendations resulting from an investigation will be submitted in report form to the General Superintendent of Maintenance, the Superintendent of the Maintenance Group concerned and all other recipients of the original Service Request.

An approval slip is to be attached to the reports sent to the General Superintendent/s who approved the original request and the Maintenance Superintendent/s concerned, requesting approval or comments.

Recommendations

The completed approval slips are to be returned to the Superintendent of the Maintenance Improvement Group within the period specified (usually 7 days). Where approval is withheld, supporting reasons must be given for follow-up by Staff Engineer concerned.

Following approval, the Staff Engineer concerned will be responsible for developing the recommendations to such a degree that they can be readily administered by line supervision. If necessary, this will include the provision of detailed procedures, craft schedules and instructions, materials and spares lists and any other information which may be required to facilitate effective work scheduling and execution.

Standard Design Instructions

Before closing a job the Staff Engineer will be responsible for informing appropriate staff of any improved materials, equipment and methods which it is intended will be adopted as Local or Company Standards and incorporated in future equipment and project designs.

The information will be prepared as a Works Design Instruction. After signature approval by the Works Manager, copies will be issued in accordance with agreed distribution for Works Design Instructions.

Following

After 12 months maintenance operation and earlier if practicable, the Staff Engineer will be responsible for reviewing each improvement study and reporting whether the original objective has been obtained or if further improvement is needed.

TO	SERVICE REQUEST MAINTENANCE IMPROVEMENT GROUP	REQUEST No. DEPT. No. LOCATION
INITIATED BY	DATE	CATEGORY
APPROVED SUPT.	GEN. SUPT.	
ASSIGNED TO	DATE REQUIRED	DATE COMPLETED
TITLE		

TO BE COMPLETED BY M.I. GROUP

SPECIAL INSTRUCTIONS

PRELIMINARY EVALUATION	Man Hrs.	SUPT. M.I. GROUP
TOTAL ESTIMATED MANPOWER	Man Hrs.	
ACTUAL MANPOWER	Man Hrs.	

OUTLINE OF BASIC SKILLS REQUIRED FOR A MAINTENANCE FITTER

1. INTRODUCTION

In the preparation of this training programme, the intention has been to provide a master outline covering all aspects of the craft, in order that the apprentice will receive a thorough training. It will be necessary to compile a detailed programme against each section of the master outline, detailing the departments where the particular experience may be gained. This could well involve a sub-division of the time allotted and short term training transfers to other companies or training centres. An induction period in the company of two weeks' minimum duration should precede basic training, carried out, where possible, at an approved training centre. During the third year of training, the apprentice should be given increasing responsibility. During the fifth year, the apprentice should work on his own responsibility, with the minimum of supervision.

Throughout the full duration of the apprenticeship, persistent attention to the detailed requirements for safe working should be stressed and correct procedures demonstrated, especially those relating to machinery in motion and artificial respiration.

2. GENERAL OUTLINE

A.	Basic Training (including initial induction programme)	12 months
B.	Fitting Shop	6 "
C.	Machine Shop	6 "
D.	Plant Services and Inspection	15 "
E.	Plant Erection and Testing	6 "
F.	Technical Services	3 "
G.	Advanced Work	12 "

3. BREAKDOWN OF PRACTICAL TRAINING

A. Basic Training - 12 months

The main aim during this period should be to impart to the apprentice a good working knowledge of basic engineering principles. Persistent attention to the detailed requirements for safe working should be stressed, and correct procedures demonstrated, especially those relating to machinery in motion. The work covered should be of a useful and interesting nature embodying simple basic exercises, which should be incorporated into assemblies during the latter part of the course. Stress should be placed on the interpretation of the workshop drawing, with ample attention being given to dimensional and quality inspection. An appreciation of costs and method analysis forms an important part of the basic period.

Instruction should be given in:-

(a) Bench fitting, leading to precision handwork.
(b) General fitting, including metal joining processes, pipefitting and simple sheetmetal work.

(c) Machine tool practice, to include centre lathe, vertical and horizontal milling, shaping and grinding.

Section 1 should be included in the basic training and induction period:-

(1) Workshop rules and routine; cleanliness and hygiene; Factory acts as they apply to employees; safety appliances and procedures in case of accidents; explanations of products and services of company.

(2) Bench-work instruction and practice in the use and care of tools, spanners, torque wrenches, hand scrapers, files, hacksaws, screw drivers, calipers and dividers, taps and dies, reamers, cold chisels, hand and electric drills.

The special conditions necessary for satisfactory service. Importance of alignment. Lining up and checking alignment of connecting equipment.

(2) Drives -
Chain, vee-rope, belt, friction and all gear drives, care and maintenance. Electric motors, mounting and coupling. Shaft couplings, advantages and disadvantages of various designs.

(3) Lubrication -
First principles and their applications. Grooving of bearings, Installing lubrication systems.

(4) Use of Portable Power Tools -
Instruction in the use of pneumatic hammers, impact wrenches, grinders and drills and electric grinders and drills.

(5) Hydraulics -
Systems, making joints and packing glands. Removing air locks. Pressure relief valves and their function.

(6) Steam and Air -
Services, boilers and pipe lines. General pipe fitting, flanges, valves etc. Safety devices - valves, bursting discs, pressure switches etc. To include maintenance and overhauls of boilers and auxiliaries. Familiarisation with special purpose flanging machinery.

(7) Transport -
Routine maintenance of transport including fork lift trucks.

(8) Electrical Safety -
Recognition of dangers and precautions necessary for safe working. Linking of electrical load to mechanical should be explained and demonstrated. A short appreciation of instrumentation as available should be included.

(9) Press and Tool Setting -
Operation of presses. Assembly of dies, tools and maintenance checking and adjustments.

(10) Company Processes -
The extent to which sections (1-9) above can be covered will depend upon company facilities and will of necessity be the subject of a separate detailed study, into which, where possible, the listed sections can be phased. There may arise, however, the need for outside experience. In arranging coverage of the company processes, both the Training Officer, and Supervisory Engineers should ensure that the following points are well developed in the apprentice.

Intimate knowledge of plant geography - know where all maintenance spares and equipment are kept. Functions of plant in relation to production processes. Know sources, pressures and flow of gas, steam, cooling water, fuel oil, oxygen, compressed air, hydraulic oil or water. Isolation of plant. Special equipment. British standard and other appropriate coding systems for pipeline identification. Location of safety equipment and operation of safety rules and procedures.

E. Plant Erection and Testing - 6 months

(1) Installation of new equipment working from plant layout drawings, and piping flow sheets. Importance of alignment, foundations, securing and grouting in. Special precautions to avoid distortion. Machine guarding of new equipment. Testing and commissioning.

(2) Advanced fitting, maintenance and repair in situ. Installation and removal of large components.

(3) Lifting tackle and slinging - Safe practice in the use of chains, wire rope, hemp slings and pulley blocks. Signals to crane drivers. Screw and hydraulic jacks. General principals of rigging. Demands of the Factories Act.

(4) Project development work under general guidance of engineer or foreman.

F. Technical Services - 3 months

Towards the latter part of the apprenticeship, apprentices making good practical and academic progress should be given the opportunity of experience in a Technical Department, such as Drawing Office, Planned Maintenance Office, Factory Planning and Layout, Plant Engineering.

G. Advanced Work - 12 months

During this period, the apprentice should work with the minimum of supervision in that department to which he has proved most suitable.

4. Technical and Education Training

(1) City and Guilds of London Institute Mechanical Engineering Craft Practice

(2) City and Guilds of London Institute Mechanical Engineering Technicians

(3) City and Guilds of London Institute Plant Engineering

(4) Ordinary and Higher National Certificates.

14.3.66.

CRAFT APPRENTICE TRAINING PROGRAMMES & GENERAL PROCEDURES

1. The master outlines can be taken as summaries of the overall experience to be gained.

2. The programme indicates chronological order of experience as it should be gained. This is the basis of an apprentice loading/movement chart.

3. Check lists, where appropriate, containing the details of training and experience to be gained in a given location will assist supervision to identify quickly and control the part of the programme to be covered in his department.

   The Supervisor should have a copy of the Master Outline and Programme. This will assist in determining the previous experience gain by the apprentice. The Work Book will be of considerable assistance.

4. Reporting procedures and general control.

   (1) The apprentice to maintain a record of training by means of Work Book.

   (2) In the Work Book the Supervisor to complete a 4 weekly report also interim report if a movement from one location to another occurs within a 4 week period. These reports are made in the workbook.

   (3) The Training Officer will interview each apprentice every 4 weeks and maintain a master record. Vet the Work Book, discuss progress with apprentice and supervisor, arrange outside transfers etc.

   (4) Every 3/4 months an assessment be made - copies to management, apprentice informed. The Training Officer would action in conjunction with Supervision. Every 12 months annual assessment to be made taking into account academic progress.

   (5) The overall assessment at completion date should give indication of practical and technical proficiency also comments on personal qualities which could serve as a useful guide to company on future potential of apprentice.

APPENDIX IV

TRAINING PROGRAMME FOR APPRENTICE MECHANICAL MAINTENANCE FITTER

Year of App.	Location	Training Period	Practical Training - for details see Master Outline attached	Remarks
1	Basic Training Centre	36 to 48 weeks variable, see note	SECTION 3A Section A. (1) Induction (2) Acquisition of basic skills (3) Specialised mechanical section	To Engineering Industry Training Board approved scheme. To include company induction to approved induction programme both before and after basic training. NOTE Vacations in works and/or under Group Training Officers e.g. Industrial visits etc. Period variable until establishment of full 48 week year at Training Centre
Remainder of Programme based upon 48 weeks basic course. 2 weeks annual leave. Should the Basic Training period be less than 48 weeks the number of weeks less should be spread over the period allocated to Central Maintenance Dept. e.g. for the 1966 intake. 20 weeks Fitting Shop. 20 weeks Machine Shop. 12 weeks Fabrication Shop.				
2	Central Maint. Dept. 1. Fitting Shop	15 weeks	SECTION B. 1. a.b. SECTION B.3. (6) Safety devices, valves. SECTION B.2. advanced fitting only SECTION B.4.	During this period the following to be covered by talks and demonstrations. (i) Ref. Section D.1. Advantages and disadvantages of various bearings in various applications. (ii) Ref. Section D.2. Shaft couplings, advantages and disadvantages of various designs. (iii) Ref. Section D.3. Lubrication. First principles and their applications. Grooving of bearings. A short period of outside experience may be necessary. See attached note.

TRAINING PROGRAMME FOR APPRENTICE MECHANICAL MAINTENANCE FITTER

Year of App.	Location	Training Period	Practical Training - for details see Master Outline attached	Remarks
2	Machine Shop	15 weeks	SECTIONS B.1. B.2. a.b.c.d. B.3. B.4.	Certain aspects may require outside experience. See attached notes.
2	Fabrication Shop	10 weeks	SECTION B. 2 also pneumatic and electric grinders	
FOLLOW ON SAFETY PROCEDURES AND PRACTICE APPLIED FOR PLANT MAINTENANCE (Prior to experience of area maintenance Units)				
2	Riggers Dept.	4 weeks to include	SECTION B.3.	
		½ day	SECTION B.8.	attached to Electrical Dept.
		½ day	SECTION B.3.	" " Instrument Dept.
		½ day	Vessel entry and pipe breaking	" " Area Mechanical Supt.
				The importance of the above cannot be overstressed.
	Area Maintenance Units 1:3:4:2	*	SECTION B.4 (6) as applied on Company plant. include flanges, valves.	Area Maintenance Units - General Note In addition to acquiring experience of the listed sections, the aim should be to develop an intimate knowledge of plant geography - know where all maintenance spares and equipment are kept. Functions of plant in relation to production processes. Know sources, pressures and flow of gas, steam, cooling water, fuel oil, oxygen, compressed air, hydraulic oil or water. Insolation of plant. Special equipment. British standard and other appropriate coding systems for pipeline identification. Location of safety equipment and operation of safety rules and procedures.
		*	SECTION D.(1) Shafts, alignment, bearings.	
		*	SECTION D.(2) Drives	
		*	SECTION D.(3) Lubrication systems	
			SECTION D.(5) Hydraulics	
			SECTION D.(6) Bursting discs. Pressure switches.	

The above may be dealt with either separately or upon a combined basis whilst attached to Units 1,3,4,2 given below. This will be dependent upon Unit policy adopted from time to time. Sections marked thus * will be the subject of more advanced work whilst attached to Field Force Unit.

APPENDIX IV

TRAINING PROGRAMME FOR APPRENTICE MECHANICAL MAINTENANCE FITTER

Year of App.	Location	Training Period	Practical Training - for details see Master Outline attached	Remarks
2-3	Area Unit No. 1	8 weeks		
3	Area Unit No. 3	8 weeks		
3	Area Unit No. 4	8 weeks		
3	Area Unit No. 2	8 weeks		
3	Area Unit No. 5	12 weeks	SECTION D.6 Steam and air. Services, boilers, pipelines. General pipe fitting, flanges, valves etc. To include maintenance overhauls of boilers and auxiliaries.	See general note - area maintenance unit. - Boiler inspections. Since these may not fall within the period allocated, special arrangements should be made for the apprentices to be present when they take place.
3	Motor Transport Section	4 weeks	SECTION D.(7)	
3	Construction Department	8 weeks	SECTION E. (1)	Testing as carried out to be included.
4	Central Maint.Dept. Field Force Unit	38 weeks	See Area Maintenance Units. Sections marked * plus SECTION D.(4) pneumatic hammers, impact wrenches and drills. Electric drills. SECTION D.(6) Special purpose flanging - machinery. SECTION E.(2) Maintenance and repair in situ. installation and removal of large components.	More advanced work than that previously undertaken - Outside experience may be necessary.

TRAINING PROGRAMME FOR APPRENTICE MECHANICAL MAINTENANCE FITTER

Year of App.	Location	Training Period	Practical Training - for details see Master Outline attached	Remarks
4	Planning and/or Drawing office	6 weeks 6 weeks	SECTION F. Technical Services	To be arranged provided good practical and academic progress has been maintained. It will be necessary to consider the detailed nature of the technical training for each trainee as it arises. It may be desirable for the apprentice to gain further practical experience during this period.
5	To be arranged in the company	50 weeks	SECTION G. Advanced Work	During this period the apprentice should work with the minimum of supervision on that section of the company in which he has proved most suitable. The work should be varied as much as possible to give broad experience. During this period special attention could be paid to manufacturers courses, short course in instructional techniques, etc.

Outside experience notes

Although it is expected that the majority of the programme can be met by 'in works' training, continuous attention should be paid to aspects that may not be covered due to circumstances prevailing. In particular outside experience should be considered for the following:

(1) Section B.3.
(2) Section C. (1) Multi-spindle drills. Band saws, straighteners, presses.
C. (3) Universal milling.
C. (4) Surface grinding. Cutter grinding.
(3) Section D. (6) Special purpose flanging machinery.
D. (9) Press and Tool setting.

Arrangements for outside experience to be actioned by the Training Officer.

APPENDIX V

Paper presented by J.J. Edwards, C.Eng., M.I. Mech E., F.I.Plant E., General Superintendent of Maintenance, Monsanto Chemicals Ltd., Ruabon, to Merseyside & North Wales Branch of The Institution of Plant Engineers on 19th September, 1968.

THE SUPERVISOR

INTRODUCTION:

My talk will be principally about foremen engaged in supervision of maintenance personnel. However, as the term "supervisor" is more descriptive of the job I use this title for the paper rather than the traditional title foreman.

Most of my experience in this respect is related to process industry, specifically the chemical industry. However, these circumstances probably involve more severe man management problems than in other industry.

With the engineering and production industries, the supervisors technical knowhow is more important than in the process industries. This technical knowhow is chiefly a matter of training and must be allowed for in selection and training of supervisors. Even so, I suspect that even in these industries the man management aspect is the one which proves the most difficult to resolve.

Why talk about supervisors at all? Surely they have been around long enough for us to know all the answers.

I have found since getting involved in maintenance management that, sooner or later, whatever I am doing the supervisor comes into the reckoning. Ultimatel success or failure of any plans laid by more senior management depends on the supervisor. He holds a vital and unique position in any organisation. It is only through him that the organisation can produce any results. The most sophisticated and technically feasible enterprises can come to nought if the supervisor is incapable of dealing with his part of it. He is the vital link between planning and execution.

Its rather like having the most expertly designed racing car with the most powerful engine in the class and no transmission shaft to translate all the technical brilliance into the end product - speed.

Increasing competitive pressure and rising labour costs put more and more stress on the need for effective man management. Yesterdays answers no longer meet the problem.

I have never been a foreman, so what then are my qualifications for talking to you on this subject?

During the whole of my working life, except perhaps for the time spent in a Drawing Office, I have been in constant contact with foremen, working for them, learning from them, advising them technically, obtaining information from them and, in latter years, working with and controlling them. My experience covers the engineering industry, construction work and the chemical industry.

At a rough count I discover I have had direct working contact with somewhere in the region of 40 to 50 foremen.

The Foreman's Job

Let us now get down to the subject at last by asking ourselves what a supervisor's job really is.

Simply stated, the supervisor's job is to make the most efficient use of manpower.

Like most simplifications it is more easily said than done. Perhaps I can start with a lighthearted interpretation. This is a little piece entitled "The Supervisor's Prayer".

"Dear Lord, help me to become the kind of supervisor my Management would have me be. Give me that mysterious something which will enable me to, at all times, satisfactorily explain policies, rules, regulations and procedures to my workers even when they have never been explained to me.

Help me to train the uninterested and dimwitted without ever losing my patience and my temper, give me that love for my fellow men so that I may lead the obstinate, no-good worker into the path of righteousness by my own example, by soft persuading remonstrance instead of punching him on the nose.

Teach me to smile if it kills me. Make me a better leader of men by helping me to develop larger and greater qualities of understanding, tolerance, sympathy, wisdom, perspective, equanimity, mind-reading and second sight.

And when, dear Lord, thou has helped me to achieve the high pinnacle my Management has prescribed for me and when I shall have become the paragon of all supervisory virtues in this mortal world - Dear Lord, move over. "

APPENDIX V

Communication

A bit of a smile, but when you think about it, its not so silly after all. Lets look at the first part about explaining; policies and rules. Keeping his men informed is a very necessary part of the supervisor's job.

A man who knows the rules, and perhaps what is more important understands what the rules are in aid of, is half way to keeping them.

The next point, policies. Company policy is never a static thing. Even less so when it gets down to day to day operating policy. Product requirements can change at short notice, such as when a salesman lands a long angled catch, when a competitors new plant fails to take off on time, or as happened to us when the Welsh Nationalist Army blows up a water pipeline. A foreman must explain these things to his men. A man must know why he has to leave the job which was urgent yesterday. He must understand why he is asked to work overtime on a job which he knows has been untouched for weeks. If he does not understand these things, he has no confidence in management, he does'nt care about the job. When he does'nt care, he does'nt work well.

To explain, the foreman must understand himself. He must also understand why his men must be informed. He should see this as a means of easing his own job.

The foreman, of course, must depend on his next in line to receive the information. Lets hope there are not many foremen in the state of the man who wrote the prayer - with the reasons not explained to him.

These conversations with his men are also the foremans opportunity for gauging the men's reactions. It is all too easy for management to fail to appreciate causes of unrest. The foreman can find out what needs to be explained.

So then we see that the foreman has an important role in communications - two way communications. To the men he is the voice and representative of management. To more senior management he must be the voice of the men.

Welfare

Communication of course is involved in most aspects of the foremans duties. One of these duties, which he must not neglect, concerns the welfare of his men.

Holiday entitlements, sick leave, time off, restricted duties and similar questions must be dealt with promptly, fairly and humanely. This is the big opportunity for the foreman to develop the team spirit within his group. Men respond more effectively to a little human consideration than to any other form of motivation, and I would include pay.

Welfare _Cont'd._

The foreman's boss must be careful here that he doesn't put his foot in it. The foreman's decision must be supported in the eyes of his men. If a decision must be reversed the reversal must be seen to be the foreman's decision, if at all possible.

The foreman must be allowed some discretion in bending the rules. He must be allowed to decide for instance that a man can take time out for a smoke or rest, secure in the knowledge that his boss will consult him on the subject before tackling a man for an apparent misdemeanour.

Discipline

Discipline is equally a foreman's responsibility. But again, he must be supported in his decisions as far as possible.

It is very necessary here to make sure the foreman fully understands the extent and limitations of his authority. Equally, he must understand that he has the responsibility of weighing the facts carefully before reaching his decision. Obviously, no unjust decision can be backed by his superiors.

Most young, inexperienced managers, myself included in my time, get into trouble in the communications field between foreman and man at some time or other.

In my case, I was fortunate in working with a very experienced foreman He told me in no uncertain terms where I was out of line, and I added one more experience to my storehouse.

Training

The next point in the prayer is a plea for help to train his men.

Most of the larger organisations nowadays have some sort of training organisation. You might say that these are the people whose job it is to do the training - not the foreman. This may be so to some extent. Even so, the foreman has some very definite training responsibilities.

Firstly, he above all is in the best position to assess what training is required. He can see the weaknesses in job performance. He can see the use, or otherwise, that is made of new tools and techniques. He is best placed to advise where his men's knowledge of the function and operation, or maintenance needs, of production equipment is deficient.

So the foreman then can be invaluable in assessing training needs - but does his responsibility end there?.

APPENDIX V

Training Cont'd.-

I don't think so - Not only is the foreman best placed to advise on training, he is the best man to carry out at least some of the training. He is the man who knows the men best and the one they will talk to most readily. The foreman is the one who will be assisted most directly from the results of effective training. He then has a vested interest in making sure the training is done properly and is understood by his men.

Another advantage to be gained is the consolidation of the foreman in control of his men, as their rightful leader, as a man they can respect.

If the foreman does so much training, what then is the purpose of the training department?.

The foreman is a busy man, he cannot spend the time preparing the training information or the training programme. He must receive the necessary training or instruction himself. The information and props must be put in his hands. He must learn some of the techniques of training. The training facilities must be organised.

The foreman is the man in the front line, the training department is one of his support groups behind the line.

Safety

In talking about training I have dealt principally with training to improve job performance. There is, however, an even more important training function - Safety training. I have deliberately separated this from job training. Not because it can be separated from job performance but because it is essential to be specific about safety.

I have seen it stated recently that one of the greatest diservices done to the cause of safety was the coining of the phase "Safety First".

If we really meant safety first, no-one would ever leave their homes, and they are dangerous places by all accounts. What we really mean is proper attention to our endeavours to make sure that known hazards are guarded against. At Monsanto we use the term "Safe Production".

How best to achieve this is a matter that we have not solved yet. One thing we are certain of though, is that the foreman's part is a vital one. It is proper that the safety theme should colour every aspect of the foreman's duties.

In training he must carry out safety training personnally. The safety and training departments have a joint responsibility for safety training. They can deal with specific aspects of the subject, can deal with general topics and teach safety philosophy. But when it gets down to doing the job on the shop floor, or on the plants, once more the key man is the foreman.

Safety Cont'd.

As part of the job instruction he must make sure that the man is fully aware of potential hazards on the job and what precautions are necessary. A major difficulty he may encounter here is the man's own familiarity with the job. Unless the foreman is careful in his approach the man may resent being told what he already is aware of. The less wise may even be tempted to take unnecessary chances to prove they know better.

Perhaps questioning the man on what precautions he intends to take may be the answer here. It is an approach we are trying. As I said, we don't know all the answers but we do feel sure that it is essential for safety to be discussed at the job instruction phase.

It is also essential that the foreman follow through with the safety philosophy. Unsafe practices must be stopped, unsafe tools must be barred, proper equipment for protection, access etc. must be supplied before the job is allowed to proceed. These factors must be observed even if this means job delays. Anything less than this will leave the foreman open to criticism of preaching safety only when it suits him.

The philosophy of "Safe Production" requires the common sense application of practical precautions which the men can appreciate and see the sense of themselves. If the foreman can get the men to commit themselves beforehand to taking the necessary precautions, so much the better.

Regular formal meetings between a foreman and his men to discuss accidents, potential hazards and current safety precautions can also be useful in establishing the foremans genuine concern with safe working.

Job Instruction

Safety instruction is only a part of job instruction. Job instruction is an art in itself. I never cease to be surprised by the number of different interpretations which people can apply to the simplest instruction. My secretary, with a little thought, can produce a document which basically can be interpreted to be what I asked for. At the same time, it can be far different from what I had in mind when I gave the instructions. Not infrequently, it is a better layout than I had in mind.

How much more difficult it can be then to put across instructions on a complex maintenance job.

Very often job instruction must include a good deal of description of why the job is necessary and what the objective is.

Job Instruction Contd.

The job must be described, pointed out, discussed and finally the foreman must obtain reassurance from the man that he has correctly interpreted the instruction.

The wise foreman will draw on the mans accumulated experience in the instruction process and guide the man to arrive at the right or required method by his own thought processes. This may sound to be a rather unnecessary procedure. Some foremen would say "A man is there to do as he's told".

In my experience, this type of foreman never becomes the "star" man. All too soon he gets frustrated by lack of results and falls back on blaming lack of energy on the part of his men.

Another foreman by getting results can develop a team spirit with his crew. Because they succeed they believe in their superiority and will work to retain their reputation.

Every good foreman develops his own way of dealing with this sort of thing. I don't really know whether it is a thing that can be taught.

One successful foreman I know uses a brand of outrageous flattery at times. I have heard him say to a man "As soon as I saw this job I thought of you right away, you're the very man we need" - these jobs, incidently, often tend to be the dirtiest or most awkward. The man did'nt really believe the flattery and was well aware of what it was all in aid of. However, he appeared to enjoy the charade and was prepared to play along to the extent of putting that little extra into the job. Obviously this is'nt an approach that can be recommended as a standard procedure. It requires first establishment of understanding and respect between the two parties.

The same foreman would, of course, vary his approach with different men and with different circumstances.

This type of foreman can make giants of the meekest, and can make the unreasonable reasonable. This is how he leads the obstinate into the paths of righteousness.

He knows the man who needs persuading, the one who needs driving, the one who must be encouraged and the one who can be stung into action by criticism. He realizes that to succeed in his own job he must be prepared to play the game according to its rules. This is an approach which I have seen applied unconsciously by some foremen who have a natural flair for it. In other cases, the foreman is consciously applying these principles.

This is the reason that I feel there is scope for passing on these skills to those not naturally endowed. However, it is only possible to pass on the idea. The Individual foreman must develop his own technique with practice.

Job Supervision

After job instruction comes job supervision. Despite the clarity of job instruction and the strength of job motivation applied to the man at the start of job, follow up is necessary.

Here again, the foreman must rely on his judgement of his men to decide how frequently they must be visited on the job. Who can be relied upon to overcome problems, and who will need help.

Talk of supervision of work always raises the question of how many men can a foreman effectively supervise.

I do not think there can be a straightforward answer to this question. There must be a series of answers related to different circumstances.

For instance, in a workshop such as a welding or machine shop upwards of twenty men can be effectively supervised.

On a single major maintenance job perhaps fifteen to twenty men can be supervi

On a collection of small scattered jobs, each involving two or three men, it is doubtful if really effective supervision can be given to ten men.

I would imagine also that the ratio of manpower to supervision on production work where each man has a set task can be a good deal higher than with a maintenance situation.

If the foreman is to supervise effectively then, he must also be an active prefers to be out and about to sitting in an office.

This requirement in itself presents a problem. Every foreman has some paperwork to handle, which I will be referring to shortly. The active outdoor foreman is inclined to be averse to paperwork. In selection then compromise is necessary. We must be prepared to submerge some of our desires in favour of t

Administrative Responsibilities

We have dealt up to now principally with the man management aspects of a f job. I think that most people will agree that this represents at least 75% of his responsibilities. Deficiencies in these areas are too serious to be outweighed by other qualities. By the same token, deficiencies in application to the other 25% of his duties can be well outweighed by strengths in his man management capabilities.

Because of the pressing need of effective man management, the remainder of a foreman's duties, the administrative work must be reduced to a minimum. It would be very nice if we could eliminate it altogether.

Unfortunately, this is not possible. There are some jobs which only the foreman can do. Others it is more convenient for him to do, or it is not economically justifiable to get someone else to do it.

If you can justify employing a clerk to do some of the foreman's bookwork, you could better justify an extra foreman to spread the load both of the man management and the administrative work.

Job Preparation

To take the first case of the work only the foreman can do. This can be generally grouped under the heading of job preparation.

The Planning or work preparation group can be left to deal with the major part of this work. From receipt of work orders, right through to issue of the job to the execution group.

In the job preparation stage it is necessary to be thinking of who, how, where, when and what with. As the man who ultimately will be responsible for the job, the foreman is, or should be, vitally interested in the planning stage.

He is best placed to appreciate the physical problems involved. His first hand knowledge of his resources and capabilities of his men demand that he should be consulted. Problems of job manning strength and services required are in his province. An experienced planner can probably deal quite effectively with most of these problems. Nevertheless, the foreman must take an interest and have his say in approving or rejecting the plan.

This may take care of the who, how, where and what with. The when still need to be settled.

Scheduling of the job is again of vital interest to him. He must know what the priorities are and what is expected of his group, and must object loudly and long if he doesn't agree. He must endorse the plan if he is to take the responsibility.

A word about the planner.

The planner/foreman relationship is one fraught with problems of split responsibility. These are problems which can only be resolved at a personal level between the two of them.

The complaint, "Who does he think he is, telling me what to do" on the one side and "Why doesn't he do the job as planned instead of going his own way" on the oth shows a lack of realisation of both sides of their joint responsibilities. This sort of relationship can produce worse results than the foreman working entirely on his own.

This sort of problem can develop very quickly between quite reasonable people but fortunately doesn't last very long with the more intelligent of these. When th pressure is on they soon realize the need to work as a team. Interchange of duties between them often produces a quick change of mind in the less adaptable as they come to realize one anothers problems.

When we look at the jobs it is more convenient for a foreman to do we arrive at a stage where it is necessary to look into the economics. This is an easy thing to say but not so easy to do. Generally, what is meant when people use that phrase is to have a look to see whether a convincing enough case can be made to get top management approval. Some assistance can be obtained by use of work sampling techniques to determine activity levels and highlight the problem areas. If one f for instance, a low activity level and high proportion of standing time coupled with a high backlog and unsatisfactory plant availability, it is fair to assume that more supervision is necessary.

How then can we get more supervision.

More supervisory time can be made available either by increasing the number of foremen or reducing the non-supervisory duties of the existing foremen.

It is in this area that the jobs that the foreman does for convenience must be studied. These jobs can range from plant inspection duties right through to checking time cards and cost allocations.

Plant Inspection

Plant inspection is a very necessary part of any maintenance planning system in the absence of a person or group specifically allocated to such duties, the foreman must carry some of the load. Indeed, even with an inspection group, the foreman, as the man on the spot, can often provide valuable information. It must then be recorded and put into the record system. I have never found many foremen reluctant to carry out inspection work but they often have a different attitude to recording the information, and generally this is the most time-consuming part of it.

Time Booking

Time booking duties are duties which cannot be neglected and again, as the man on the spot the foreman almost inevitably is involved.

Cost Allocation

Necessary to a maintenance organisation for cost control and maintenance investigation purposes, also usually comes the foreman's way. We have tried different methods of handling this chore without any real success. These methods included getting the men to make them on completion of jobs and also using a clerk. Both methods led to such serious inaccuracies that they were abandoned. We have now settled for a simple system of tear off cards, which reduces the writing duty to a minimum.

Another chore which can consume a good deal of a foreman's time is requisitioning of materials.

This again, we have attemtped to reduce to a minimum. Initially, the planning group can organize the main items required.

General engineering goods, bolts, joints, small valves, fittings, piping etc. are held in open access stores at strategic points throughout the works. These stocks are replenished automatically to a predetermined level by a stores delivery service. This works together with a regular delivery service and an electro writer system of placing requisitions on the stores from transmitting stations located in different parts of the Works.

The temptation for a foreman to supply a personal materials delivery service is therefore reduced, but as yet. not altogether eliminated.

A good foreman is, by definition, a concientious and energetic man. It is his very impatience with delay and his energetic nature which all too often leads him into inefficient ways. If he has not developed the habit of planning ahead, his materials and equipment requirements are always urgent and the best delivery service too slow.

It is only by letting a foreman see that his time is valuable and that it is most usefully spent on supervision that he can be led to do his best job.

This leads us naturally then to foreman training.

Foreman Training

As with all training, catching them young is likely to yield the best results. This is not to say that training of the older established foreman should be ignored. However, it is by training of the younger men that we have achieved some of our most promising results and it is about this aspect I wanted to talk principally.

A word first about foreman selection.

Selection

I suppose the most common method of foreman selection is via promotion from the shop floor to changehand and thence to foreman when a vacancy occurs.

Some years ago, it was decided to abolish the changehand system at Orabon. The number of foremen was increased, mostly from the changehand group, and changehands disappeared. For a number of years thereafter due to our low staff turnover and the ages of the foremen there was little demand for new foremen. Holiday and absence cover was dealt with by temporary appointments from the work force.

Increasing economic pressure and passage of years gradually changed the situation and a need for a planned approach became evident.

As a result, a Potential Foreman Training Scheme was developed and put into effect.

Applications were invited from the workforce and selections made of suitable candidates after intelligence tests, mathematical and written exercises and intervie

In the interview we looked for a number of things. The major ones being the personality and character of the man himself.

If one tried to write the ideal specification for the man it would sound too good to be true. A reasonable compromise is necessary in selection, providing the essential qualities required are present.

For instance, the man would need to be:-

Fit and active.
Ambitious.
Determined, self reliant and strong willed but ready to listen to and appreciate a reasonable argument.
Not influenced by mass opinion or reaction.
Have a logical mind and be capable of innovation.
Be interested in people.

Training Programme

A training programme was developed with classroom sessions at roughly monthly intervals. These were generally conducted by maintenance staff personnel. They included talks on maintenance and works organisation and systems, maintenance philosophy, policy and objectives, job instruction techniques, foremanship and so on. Some use of outside courses was also made.

All absence cover was carried out by potential foremen and they were allocated to special assignments in planning and the maintenance improvement group.

Training Programme Cont'd.

In this way, over a period of a year or two, they become familiar with the ways of the department and its objectives. In addition, a feature which I personally feel is most important, they came to know maintenance staff in a different sort of relationship than had been possible before. This is necessary if the man is to divorce himself from his shop floor thinking, ties and allegiances. It is a process which cannot be accomplished overnight.

From a financial point of view the job was attractive. While performing temporary and special duties they received an increased hourly rate. In addition, they were still able to take advantage of their share of available overtime in their work group.

Progress was reported after every spell of duty and an annual review carried out. Any candidate who proved unacceptable was dropped from the group and the remainder retained.

When foreman or planner vacancies occurred, applications were invited and selections made after interview by the department head concerned.

The need to study training requirements for these potential foremen had beneficial side effects in strengthening the training programme for existing foremen. In addition, there was a general increase in awareness and understanding of foreman needs throughout the maintenance management team.

This scheme has proved a most useful source of young talent to restock our first line supervisory and planning group. So much so, that it awakened interest in the Production Departments who were also beginning to face an ageing foreman situation.

The Maintenance Department scheme has now been adopted as a basis for a factory wide scheme.

The new scheme will incorporate all the best features of the original programme but will be conducted as a full time training programme over two years.

It is aimed to staff the scheme to meet the factory's future need and to give candidates reasonable expectation of achieving staff grade at the end of the training period.

More use will be made of outside courses but there will still be ample room for instruction by works staff and for periods of acting duty.

In recent selection of candidates for the scheme, a new problem has started to show itself.

Having raked over the available talent through the years we are running short. Our source of new talent from within the works is most likely to come from the ranks of time served apprentices.

With the present trends in education, potential foreman material will possibly get better educational opportunities and are more likely to end up in the technician category rather than in craft ranks.

This suggests that there will be less potential foreman talent coming into craft ranks in future.

In apprentice selection we are now looking for our future talent. It's a difficult, long range forecasting job but one we feel is necessary.

SUMMARY

Summarising then, we can say that a foreman's main responsibility is man management.

Factors included in this aspect are:-

Communication with his men and to his boss - conveying company policy, general information, rules and regulations, job status reports, problems and shop floor opinion.

Other duties include:-

Welfare
Discipline
Training of his men
Safety
Job Instruction
Union Relations

His other responsibilities can include:-

Job Preparation
Plant Inspection
Time booking and cost allocation
Materials requisitioning

What qualities then do we have to look for in selecting a foreman?

He must be intelligent and must have the necessary technical knowledge of the job. This does not necessarily mean that he must be the best craftsman in the shop.

He must possess that indefinenable quality "leadership".

I have deliberately avoided using that word up until now. I have tried to show what results a good leader will achieve, as I feel this is of more pratical value than trying to define leadership.

Selection of foremen then must be aimed at identifying these qualities in the candidates.

Necessary compromises of course must be made, providing essential qualities are present.

Subsequent training can then be directed at developing the latent talents and passing on the necessary information on organisation and procedures.

A planned approach to supervision and its problems is necessary nowadays. The old chance methods are no longer sufficient to meet the more demanding requirements of competative industry.

APPENDIX VI

Example of Maintenance Workshops for Chemicals Manufacturing Organisation Employing Approximately 500 Production Workers

Workshop Facilities

1. Three Area Workshops
2. Field Workshop
3. Machine and Fitting Shop
4. Welding Shop
5. Civil Trades Workshop
6. Rigging Shop
7. Garage Workshop
8. Electrical Workshop
9. Instrument Workshop

APPENDIX VI

1. AREA WORKSHOP

Personnel

2 Foremen		
8 Mechanical Fitters	-	daywork
8 Pipefitters	-	daywork
3 Non craft men	-	daywork
2 Greasers	-	daywork
1 Mechanical Fitter	-	Shiftwork (1 per shift)
1 Pipefitter	-	Shiftwork (1 per shift)

Workshop Equipment

14" Rough Grinding Stone
6" Tool Grind Stone
Tubular Hydraulic Pipe Benders up to 3"
"Rapidor" Mechanical Saw with Angle Vice for Sawing up to 6"
Bench Drill with Morse Taper Chuck to 1" spare Chuck for straight Shank Drills to $\frac{1}{2}$"
"Rigid" 300 pipe threader to 2" with Dies for Screw Cutting

Workshop Tools

Set Socket Wrenches with extension Bars and Ratchet A/F sizes
Set Metric Socket Wrenches 5mm - 20 mm.
Torque Wrench
7lb. Lump Hammer
10lb. Sledge Hammer
Electric Pistol Drill $\frac{1}{4}$" Chuck
2 Electric Portable Drills $\frac{3}{8}$" Chuck
Electric Portable Drill $\frac{1}{2}$" Chuck
Morse taper Shank Drills to $\frac{3}{4}$"
Straight Shank Drills to $\frac{1}{2}$"
2 Electric Extension Leads
Electric Transformer 25 + 50 Volt
Internal Circlip Pliers
External Circlip Pliers
Hacksaw Frames and Blades
Set wad Punches
24" Stillson Wrench
18" Stillson Wrench
Dexion Iron Angle Cutting Tool

AREA WORKSHOP (Cont'd)

Workshop Tools (Cont'd)

B.S.W. Taps to $\frac{3}{4}$"
B.S.F. Taps to 2"
2 - 1" Ring Slogging Spanners
Set open ended Metric Spanners 5 mm - 20 mm.
Flame Proof Hand Torch
50 Volt Trailing Lamp

Mechanical Fitter Tool Kit

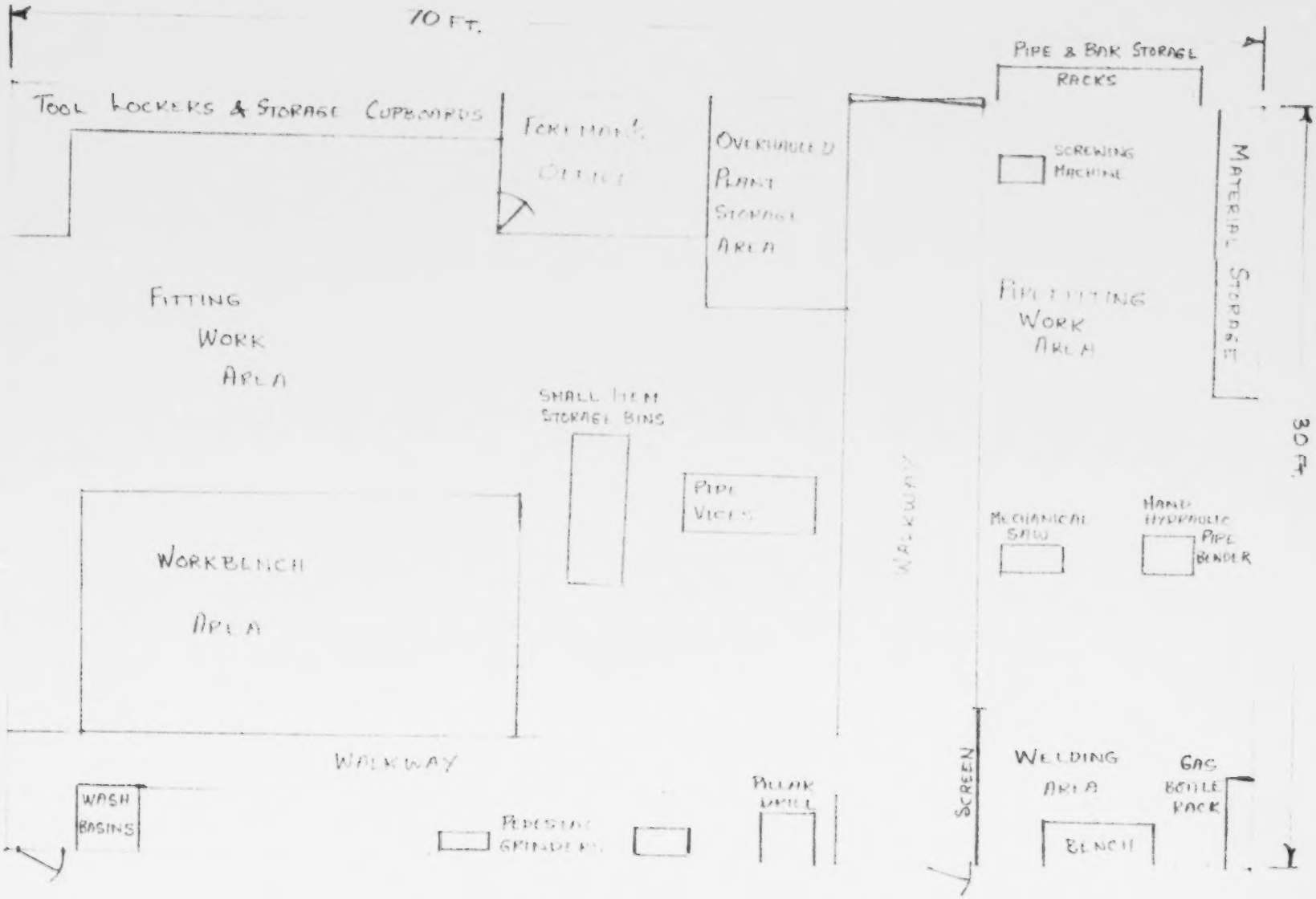
$1\frac{1}{2}$ lb. Ball Pien Hand Hammer
Centre Punch
$\frac{1}{2}$" Flat Chisel
Round Nose Chisel
Diamond Point Chisel
Cross Cut Chisel
Set Allen Keys
Stillson Wrench 10"
Screw Drivers 6"
Hose Clip Screw Driver
Off Set Pinch Bar 18" x $\frac{1}{2}$"
2 Fox Wedges - 2"
Pair Combination Pliers
Scraper $\frac{3}{4}$" Round x 6"
Scraper Flat 8"
Scraper 3 Square 6"
Spanners-Open Jaw Double Ended
Precision Hexagon Bolts, Screws and Nuts - BSW & BSF Threads 5/16" - $\frac{1}{4}$"
5/16" - $\frac{1}{2}$", $\frac{1}{2}$" - $\frac{1}{2}$", $\frac{1}{2}$" - 2"
U.N.F. 3/16" - 6", $\frac{1}{4}$" - 5/16", $\frac{3}{8}$" - 7/16", $\frac{1}{2}$" - 9/16", $\frac{1}{2}$" - $\frac{5}{8}$", $\frac{5}{8}$" - $\frac{3}{4}$".

Double Ended Cranked Ring Spanners
Precision Hexagon Bolts, Screws and Nuts - BSW & BSF Threads $\frac{1}{2}$" - $\frac{5}{8}$", $\frac{5}{8}$" - $\frac{3}{4}$"
U.N.F. $\frac{1}{4}$" - 5/16", $\frac{3}{8}$" - 7/16", $\frac{1}{2}$" - 9/16", $\frac{5}{8}$" - $\frac{3}{4}$"
U.N.C. $\frac{3}{8}$" - $\frac{1}{2}$", $\frac{5}{8}$" - $\frac{3}{4}$"

AREA WORKSHOP (Cont'd)

Pipefitter Tool Kit

1½ lb. Ball Pien Hand Hammer
¾" Flat Chisel
Stillson Wrench 24"
1 Pair Stillson Wrench 14"
Fox Wedges 2"
Pinch Bar 16" x ¾" Off Set
Combination Pair Pliers
Hose Clip Screw Driver
Spanners as Mech. Fitter


10 FT.
TOOL LOCKERS & STORAGE CUPBOARDS
FOREMAN'S OFFICE
OVERHAULED PLANT STORAGE AREA
PIPE & BAR STORAGE RACKS
SCREWING MACHINE
MATERIAL STORAGE
FITTING WORK AREA
PIPE FITTING WORK AREA
30 FT.
SMALL ITEM STORAGE BINS
PIPE VICES
WORKBENCH AREA
WALKWAY
MECHANICAL SAW
HAND HYDRAULIC PIPE BENDER
WASH BASINS
PEDESTAL GRINDERS
PILLAR DRILL
SCREEN
WELDING AREA
GAS BOTTLE RACK
BENCH

2. FIELD WORKSHOP

Personnel

4 Foremen		
16 Mechanical Fitters	-	daywork
29 Pipefitters	-	daywork
1 Welder	-	daywork
11 Non-Craft Men	-	daywork

Workshop Equipment

"Leonard" Flanging M/C

Flanges MS and SS Tube up to and including 4" N.B. by cold rolling flange on pipe end.

Bench Drill

Uses twist drills up to and including $\frac{5}{8}$".

Standard Drill

Uses twist drills up to and including $1\frac{1}{4}$".

Pedestal Grinding Wheels

Large and small

Tube Bender Electro-hydraulic

$\frac{1}{2}$" to 4"

Machine Hack Saw

Cuts M/S and SS Tube up to and including 6" N.B.
Cuts steelwork up to 6" x 4".

Abrasive Cut-off Machine

Cut all pipe and steelwork up to $4\frac{1}{2}$".
For use with 18" diameter abrasive wheels

Circular Block Saw

Used for cutting tube to be used in Flanging M/C.
Cuts up to 4" N.B.

Screwing M/C
Used for cutting threads up to 6" N.B.

FIELD WORKSHOP

Workshop Tools

2 Portable Sanding Machines
2 "Box" Magnetic Drilling Machines
"Bandit" Banding Tool
1 Battery Drill
4 Ermeto Spanners
"Bicep" Hand Truck with Hand Hydraulic Lift Platform

Mechanical Fitter Tool Kit

Ball Pein Hand Hammer 1¾ lbs. weight
Chisel - 1" width x 8" long
Chisel Cross Cut - ¼" width x 6" long
Chisel Round Nose - ¼" width x 6" long
Chisel Diamond Point - ¼" width x 6" long
Set Double Ended - open jawed Spanner for Whit Nuts
3/16th" x ¼" : 5/16th" x ⅜" : ½" x ⅝" : ¾" x ⅞" .

Double Ended - open jawed Spanner for Unified Fine Threads UNF

⅜" x 7/16th" A.F. 9/16" x 11/16th".

Set Double Ended open jawed Spanner for Unified Thread UNC

½" x ⅝" AF ⅞" x 1 1/16"

¾" x ⅞" AF 1¼" x 1 7/16"

Set Double Offset - double ended Chrome-vanadium ring spanners - Unified

½" x ⅝" U.N.C. (AF ⅞" - 1 1/16")

⅝" x ¾" U.N.C. (AF 1 1/16" - 1¼")

¾" x ⅞" U.N.C. (AF 1¼" - 1 7/16")

1 Set Double Offset - double ended Chrome-vanadium ring spanners - Whitworth ⅜" x ½" & ¾" x ⅞"

Set Allan Keys ⅛" to ½"
Stillson Wrench - 10"
Screw Driver - 6" (Wood Handle)

Mechanical Fitter Tool Kit (Cont'd)

Hose Clip Screwdriver - T. Handle
Pair Tin Snips - 10"
Pinch Bar 16" x $\frac{3}{8}$" diameter
Files and Handles as required
Fox Wedges - 1" x $3\frac{1}{2}$"
Pair Pliers 7"
Key drawer
Hacksaw
Spirit Level
Square
Feeler gauges
6 ft. Tape Rule

Pipefitter Tool Kit

Ball Pein Hand Hammer $1\frac{1}{4}$ lbs. weight
Chisel Flat 1" x 8" long
Cross Cut Chisel - $\frac{1}{4}$" x 8" long
Set Double ended - open jawed Spanners for Whit Nuts
3/16" x $\frac{1}{4}$" : 5/16" x $\frac{3}{8}$" : $\frac{1}{2}$" x $\frac{5}{8}$" : $\frac{3}{4}$" x $\frac{7}{8}$"

Set Double ended - open jawed Spanners for UNF
$\frac{3}{8}$" x 7/16" AF 9/16" x 11/16"

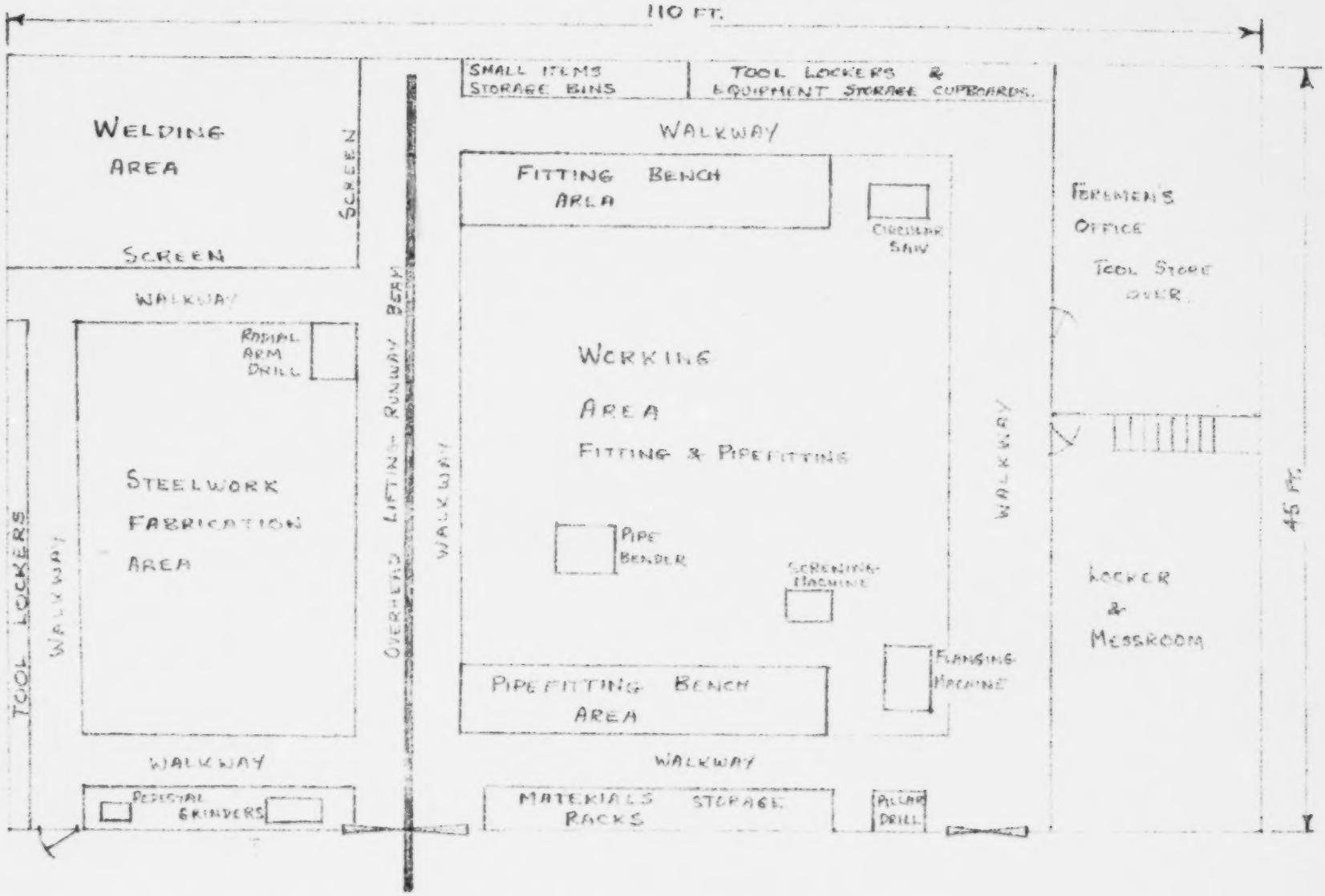
Set - Double-ended - open jawed Spanners for UNC
$\frac{1}{2}$" x $\frac{5}{8}$" AF $\frac{7}{8}$" x 1 1/16"
$\frac{5}{4}$" x $\frac{7}{8}$" AF $1\frac{1}{4}$" x 1 7/16"

Set - Double Offset - Double ended Chrome-vanadium Ring Spanners
$\frac{1}{4}$" x $\frac{5}{8}$" UNC (A/F $\frac{7}{8}$ - 1 1/16)
$\frac{5}{8}$ x $\frac{3}{4}$ UNC (A/F 1 1/16 - $1\frac{1}{4}$")

Set - Double Offset - Double ended Chrome-vanadium Ring Spanners - Whitworth
$\frac{1}{2}$" x $\frac{5}{8}$" & $\frac{3}{4}$" x $\frac{7}{8}$"
14" Stillson Wrench
24" Stillson Wrench
Files and Handles as required
Fox Wedges 1" x $3\frac{1}{2}$"

Pipefitter Tool Kit (Cont'd)

Pair Tin Snips - 10"
Pair Pliers - 7"
Screwdriver - 6"
Hose Clip Screwdriver T Handle
Hacksaw
Spirit Level
Square
Feeler gauges
6 ft. Tape Rule


110 FT.
45 FT.
SMALL ITEMS STORAGE BINS
TOOL LOCKERS & EQUIPMENT STORAGE CUPBOARDS.
WELDING AREA
SCREEN
SCREEN
WALKWAY
WALKWAY
FITTING BENCH AREA
CIRCULAR SAW
FOREMEN'S OFFICE
TOOL STORE OVER.
RADIAL ARM DRILL
WORKING AREA
FITTING & PIPEFITTING
STEELWORK FABRICATION AREA
TOOL LOCKERS
WALKWAY
OVERHEAD LIFTING RUNWAY BEAM
WALKWAY
WALKWAY
PIPE BENDER
SCRIBING MACHINE
FLANGING MACHINE
LOCKER & MESSROOM
PIPEFITTING BENCH AREA
WALKWAY
WALKWAY
PEDESTAL GRINDERS
MATERIALS STORAGE RACKS
PILLAR DRILL

ENDIX VI

3 MACHINE AND FITTING SHOP

Personnel

1 Foreman
4 Turners
4 Mechanical Fitters
2 Non-Craft Men
1 Storekeeper

Workshop Equipment

Centre Lathes

Machine No.	Swing Over Bed	Swing Over Gap	Speed Range R.P.M.	Length Between Centres	Screw Cutting Capacity
No.1	18"	26"	20 RPM - 1600	6' 6"	2 TPI - 72 TPI + Metric
No.2	16"	32"	13 RPM - 404	4' 6"	2 TPI - 28 TPI + Metric
No.3	22"	39"	13 RPM - 400	5' 0"	2 TPI - 28 TPI
No.4	22"	30"	13 RPM - 500	9' 0"	1 TPI - 36 TPI + Metric
No.5	12"	No Gap	54 RPM - 1200	3' 0"	4 TPI - 52 TPI + Metric
No.6	16"	No Gap	42 RPM - 375	2' 6"	Metal Spray Only

APPENDIX VI.

MACHINE AND FITTING SHOP

Mechanical Fitter Tool Kit (Shop Work)

Sets of Spanners

Whitworth	A/F	Metric
$\frac{1}{8}$ - 1"	$\frac{1}{4}$ - 1 1/16	6 mm. - 12 mm.

Screwdrivers	-	4" and 8"
Pliers	-	6"
Allen Keys (Sets)	-	British Standard and Metric
Scrapers	-	Half Round - flat - three square
Hammers	-	1 lb. - $1\frac{1}{2}$ lb. - 4 lb.
Chisels	-	Flat - cross cut - diamond point - round nose
Stillson Wrench	-	14"
Clamps	-	Tool makers and "G"
Centre Punches	-	2" and 4"
Rules	-	6" - 12" - 24" - B. Standard and metric readings
Calipers	-	Inside - outside - Dividers - Trammells - Odd legs in various sizes
Hack Saws	-	Junior and standard
Spirit Level	-	6"
Squares	-	6" and 12"
Podger Bars	-	8" and 14"
Tin Snips	-	8"
Scriber		

APPENDIX VI.

MACHINE AND FITTING SHOP

Workshop Tools (Toolstore also serves as central store for total maintenance workforce)

Hydraulic Drawing Equipment	-	20 and 50 ton
Small Screw Drawing Equipment	-	4" - 12"
Broaching Equipment (Hand Operated)	-	$\frac{1}{8}$ - 9/16 Keyways
Electric and air hand drilling machines	-	$\frac{1}{4}$ - $\frac{1}{2}$ - $\frac{3}{4}$
Ratchet Drills	-	$\frac{1}{2}$" - 1"
High Speed Steel Drills	-	1/64 - 2$\frac{1}{4}$" Dia
High Speed Steel Taps	-	Whit - BSP - BSF - UNC - UNF BSF - Metric
High Speed Steel Dies	-	Whit - BSP - BSF - UNC - UNF BSF - Metric
Tube Expanders	-	$\frac{3}{8}$" - 2"
Socket Sets	-	Whit - A/F - Metric
Portable Sanders (Electric)		
Portable Grinders (Electric)		
Milling Cutters - various	-	Rotary - end mills - slot drills Woodruff
Non Spark Tools	-	Hammers - chisels - spanners
Pressure Gauges	-	0 - 1000 p.s.i.
Vacuum Gauges		
Tube Bending Equipment	-	$\frac{1}{2}$ - 3" N.B.
Mad and Bell Punches	-	$\frac{3}{8}$ - 2"
Stillson Wrenches	-	18" - 24" - 36" - 48"
Impact Tools	-	$\frac{3}{4}$ Drive
Tube Cutters	-	$\frac{1}{2}$ - 2"
Oil - Grease - Degreasing Fluid		
Cotton Waste		

MACHINE AND FITTING SHOP

Milling Machines

	No.1	No.2
Table Length	3' 4"	60"
Table Height from Spindle Centre	12"	19"
Speed Range	31-1010 RPM	28-1400 RPM

Shaping Machine

Length of Stroke	-	12"
Table Dimensions	-	17" x 11"
Table Height from Tool	-	12"
Feed Traverse	-	30"

Grinding Machines

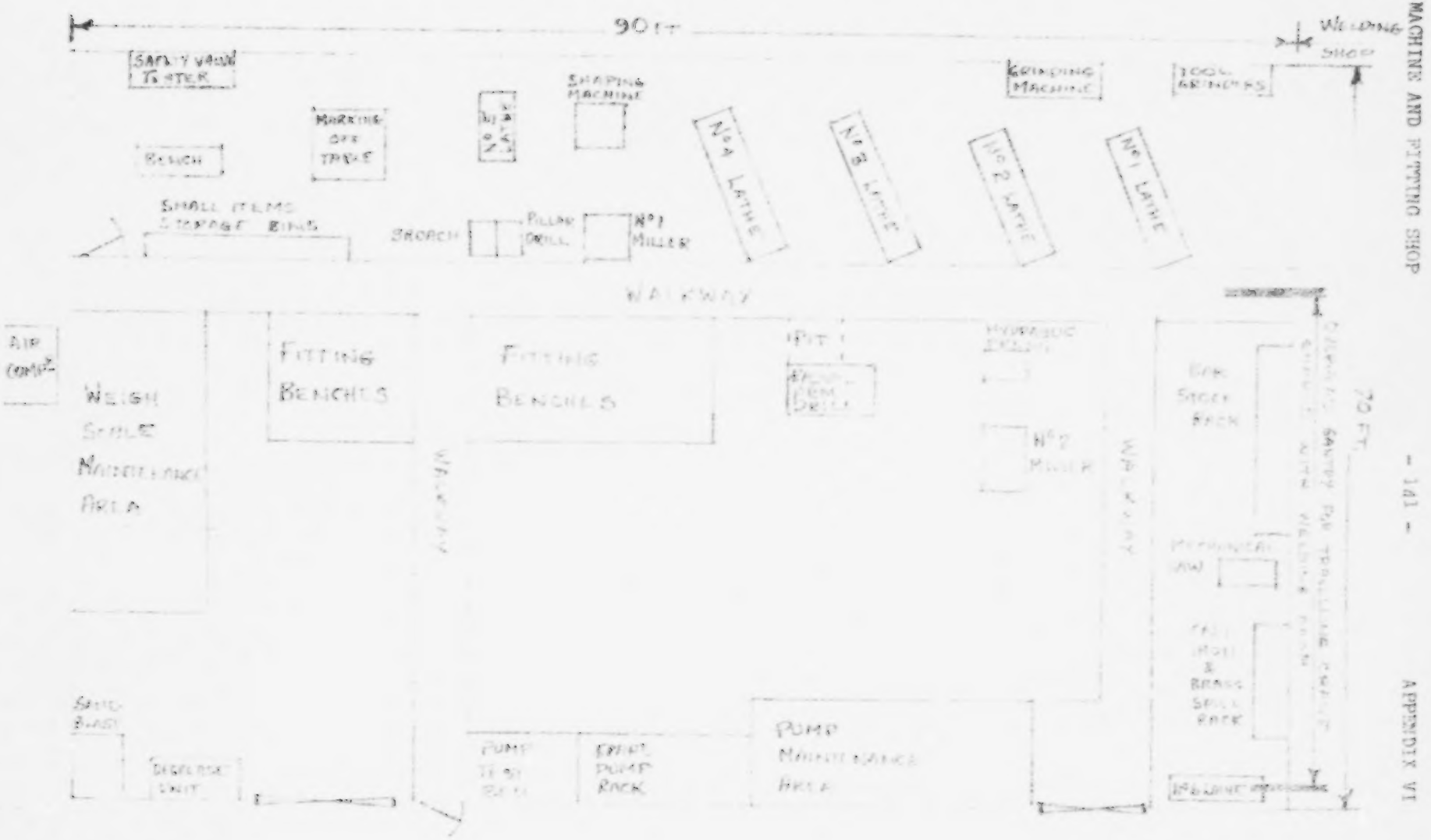
Tool Grinding Machine	-	12" dia x 2" wide Stone Size
Centre Grinder	-	3' 0" between centres 12" over bed.

Drilling Machines

4' 6" - Radial Arm - Drill Capacity - $\frac{1}{8}$" - $3\frac{1}{2}$" dia
Pillar Type Drill - 1/64 - $\frac{3}{4}$ Capacity

Mechanical Saw

10" Dia. Vice Capacity
12" Stroke


90 FT
WELDING SHOP
SAFETY VALVE TESTER
MARKING OFF TABLE
BENCH
SHAPING MACHINE
GRINDING MACHINE
TOOL GRINDERS
No 4 LATHE
No 3 LATHE
No 2 LATHE
No 1 LATHE
SMALL ITEMS STORAGE BINS
BROACH
PILLAR DRILL
No 1 MILLER
WALKWAY
AIR COMP.
WELDING SCREEN
FITTING BENCHES
FITTING BENCHES
PIT
HYDRAULIC PRESS
No 2 MILLER
WALKWAY
BAR STOCK RACK
20 FT
SAND BLAST
DEGREASE UNIT
PUMP TEST BED
EFFECT PUMP RACK
PUMP MAINTENANCE AREA

4 WELDING SHOP

Personnel

1 Foreman
14 Welders/Sheet metal workers
4 Burners
3 Non Craft men

Workshop Equipment

8 ft. Plate Guillotine Capacity $\frac{3}{8}$" M.S. $\frac{1}{4}$" S/S Plate
6 ft. Plate Bending Rolls. Capacity $\frac{1}{2}$ M.S. Plate
6 ft. Sheet Bending M/C. Capacity $\frac{1}{8}$" M.S. Plate
Pedestal Grinder 14" Abrasive Wheels. Spindle Speed 1440 r.p.m.
3 ft. Tinsmiths Rolls. Capacity 24 S.W.G.
3 ft. Tinsmiths Guillotine Capacity 24 S.W.G.
2 Banks of 8 Oxygen Cyls. Pipe all around the Shop
2 Banks of 3 Acetylene Cyls. Pipe all around the Shop
Oxy. Acety. Ring Main around s/Shop covering all benches
1 Fixed Welding Transformer with 3 pots Range 30 - 280 amps
1 Argon Welding Set Range 24 - 330 amps
2 DC Welding Sets 20 - 300 amps
1 AC/DC Welding Set Range DC 92 - 520 amps. AC Range 116 - 624 amps
1 Dual AC Welding Set Range 2 Operators 20 - 250 amps
Range 1 Operator 20 - 480 amps
1 Dual AC Welding Set Range 2 Operators 45 - 185 amps
Range 1 Operator 45 - 350 amps
11 Singe Operator Portable AC Sets Range 20 - 300 amps
1 Petrol Driven DC welding Set Range 40 - 170 amps
4 Oxy. acety. Burning and welding Sets - Portable
All Welding Sets with the exception of the 1 Fixed transformer and 3 Pots are portable
1 "Air Products Quickly" Oxy. Acety. Cutting M/C
1 Oxy. Acety. Profile cutting M/C with powder cutting attachment for S/S
A single phase 50 v. ring main supplies the shop with points accessible to all benches
An air ring main of 80 p.s.i. supplies the shop with points accessible to all benches
A travelling gantry crane operates over $\frac{1}{4}$ of the length of the Shop and is fitted with an Air Operated 1 ton Block and a Manually Operated 3 ton Block.

APPENDIX VI

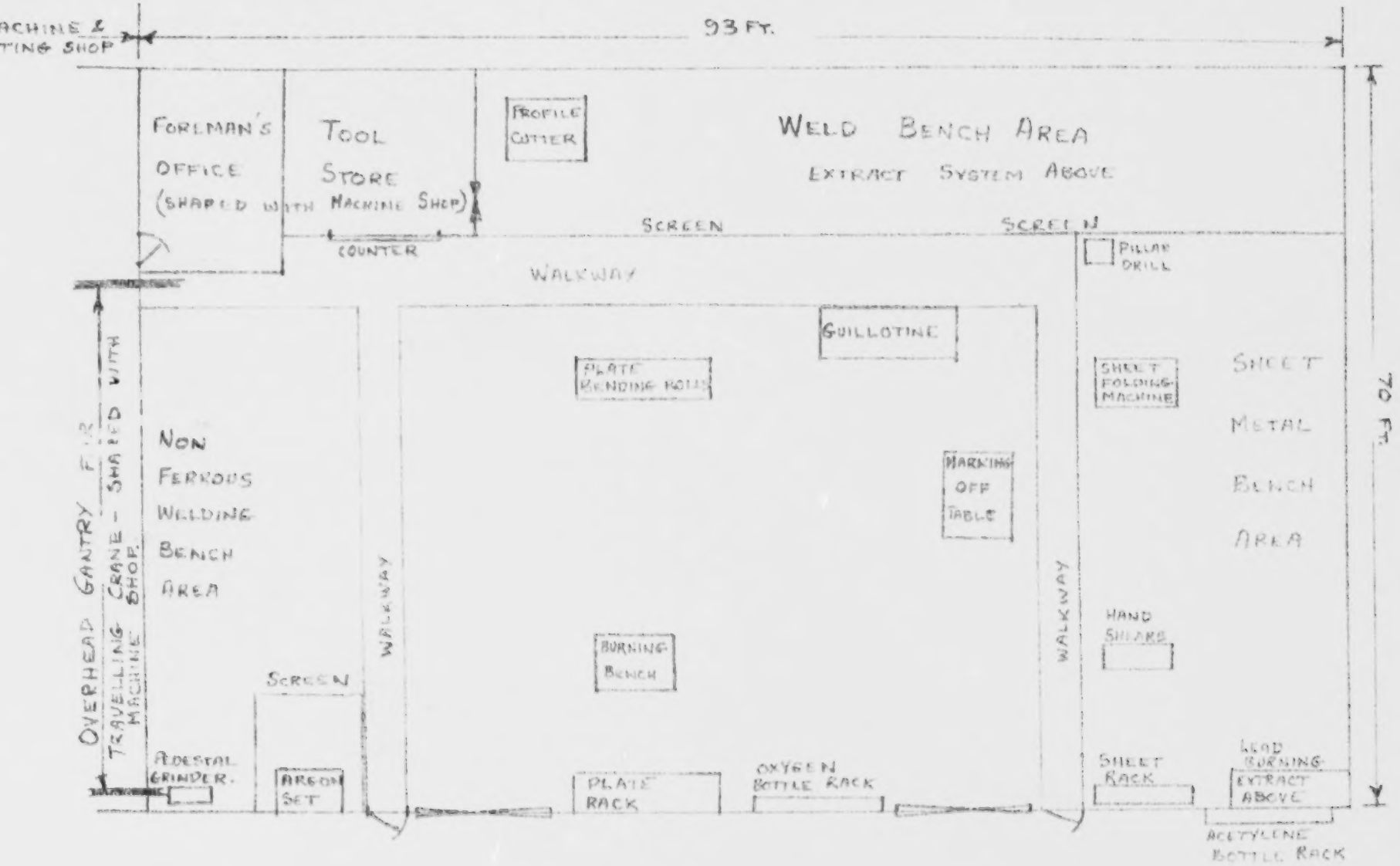
WELDING SHOP

Workshop Tools and Stores

Compressed air "Trumph" Bevelling M/C TKF 100
Chamfers 45° Angle on plate or pipe edges from thickness ¼" - ⅝"
3 - 7" Portable "Black-Decker" Sanders Electrically Operated
1 - 4" Portable "Black-Decker" Grinderette Electrically Operated
Battery Operated Pistol Drills
Air Operated Chipping Hammers
Air Operated Grinders
Various sizes of Electric Portable drills
2 "Bicop" hand trucks with hand hydraulic table lift
Jig Saws
Pop Rivet Pliers
Tungsten Electrodes for Argon Torches
Nozzles for Saffire Cutters
Oxygen Acetylene Propane and Argon Regulators
Cable for Welding and Earth Leads
Oxygen and Acetylene Hose
Grinding and Sanding Discs
Nozzles for Welding Blow Pipes
Spare Cutters for Trumph Bevelling M/C
Blades for Jig Saws

Welder Tool Kit

Ball Pein
Hammer
Flat Chisel
Round Nose Chisel
Cross Cut Chisel
8" Screw Driver
Off-Set Pinch Bar
8" Combination Pliers
Hack Saw
Centre Punch
Wire Brush
Welding Shields
Chipping Hammer
Spanners from ½" up to 1 1/16 aF
"Gilbow" Tinsnips


ACHINE &
TING SHOP
93 FT.
FOREMAN'S OFFICE (SHARED WITH MACHINE SHOP)
TOOL STORE
PROFILE CUTTER
WELD BENCH AREA
EXTRACT SYSTEM ABOVE
SCREEN
SCREEN
COUNTER
WALKWAY
PILLAR DRILL
GUILLOTINE
PLATE BENDING ROLLS
SHEET FOLDING MACHINE
SHEET METAL BENCH AREA
70 FT.
MARKING OFF TABLE
OVERHEAD GANTRY
TRAVELLING CRANE - SHARED WITH MACHINE SHOP
NON FERROUS WELDING BENCH AREA
WALKWAY
WALKWAY
HAND SHEARS
BURNING BENCH
SCREEN
PEDESTAL GRINDER
ARGON SET
PLATE RACK
OXYGEN BOTTLE RACK
SHEET RACK
LEAD BURNING EXTRACT ABOVE
ACETYLENE BOTTLE RACK

5 CIVIL TRADES WORKSHOP

Personnel

1 Foreman
6 Joiners/Carpenters
5 Painters
2 Bricklayers
4 Sheeters (For work on building roof and side sheeting)
4 Laggers
3 Building Cleaners
9 General Labourers

Workshop Equipment

MACHINE	H.P.	
Large Circular Saw	15	Capable of cutting 10" Depth
Small Circular Saw	6	Capable of cutting 5" Depth with rise and fall table
Bandsaw	4	Capable of cutting 2' 6" Diameter - 6" Depth
Cross-cut Saw	1½	Cuts to 3" depth
Wilson Planer and Thicknesser	3	Surfacing width 12½" Thicknessing capacity 7" Rebating depth 3"
Wood Lathe	2	5" Radius 3' 6" between centres
Mortiser	1	Hollow chisel type ¼" to ⅜"
Vertical Milling Machine	5	For pattern making

APPENDIX VI

CIVIL TRADES WORKSHOP

ELECTRIC PORTABLE EQUIPMENT

TOOL	
2 Speed Heavy-Duty Drill	½" Capacity. 1200 & 525 r.p.m.
140 Type D.G. Drill	¼" Capacity. 1400 r.p.m.
Heavy-Duty belt Sander	Belt Size 3" x 24" 1500/Belt ft/min.
General Duty Jig-Saw	3000 min.
Electro-Pneumatic Rotary Percussion Drill	½" to 2" Capacity
Cordless Electric Drill	¼" Capacity

AIR OPERATED EQUIPMENT

Heavy-Duty Concrete Breaker	With Spring-type retainer for use with chisel, pea-point or spade end
Hammer Drill	Dry type with coil spring retainer ½" to 2" capacity

Cement Mixer 10/7 cu. ft.
2 Wheelbarrows
6 Shovels
2 Picks
2 Sledgehammers

APPENDIX VI

CIVIL TRADES WORKSHOP

Bricklayer Tool Kit

Hand Trowel
Pointing Trowel
Plastering Trowel
Brick Hammer
Masons Club Hammer
Bolster Chisel
Assortment of Plugging chisels and drills
3' 0" Plumb level
12" Pocket Level
Plumb-bob
Chalk-lines and pins

Painter Tool Kit

Various size paint brushes
7" Flat Brush
Variety of Scrapers
Shave hooks
Dust Brushes
Blow-lamp
Paper Brushes
Paper Hangers scissors
Sanding Blocks

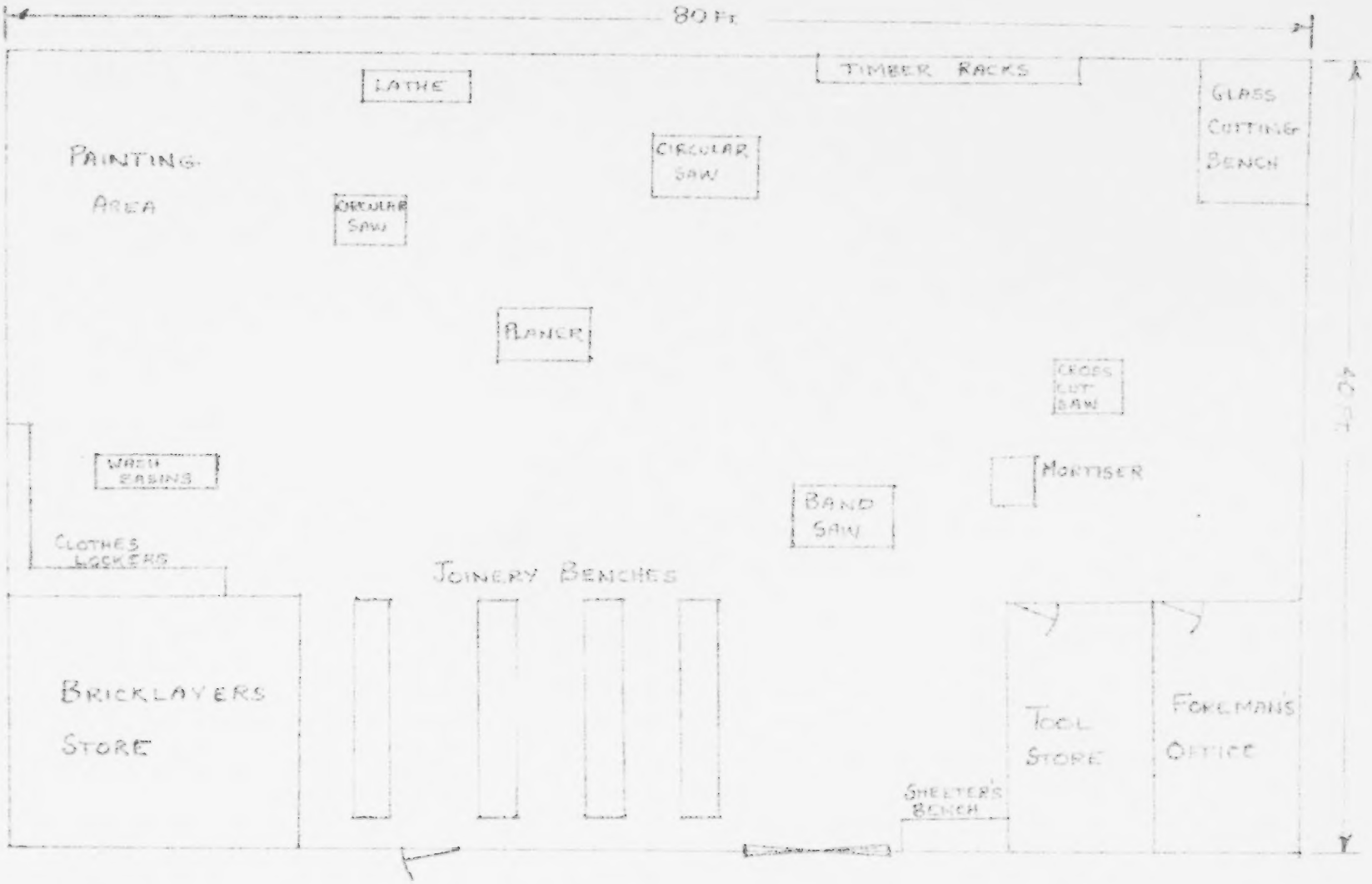
APPENDIX VI

APPENDIX VI

CIVIL TRADES WORKSHOP

Joiner/Carpenter Tool Kit

Handsaw 26" - 8 teeth to inch
Panel saw 24" - 10 teeth to inch
Dove Tail saw
Steel jack plane
Steel smoothing plane
Rebate plane
Try Square
Mitre Square
Marking Gauge
Mortise Gauge
Hand brace
Set of twist bits ¼" to 1¼" in 1/16"ths
Set of firmer chisels ¼" to 1½" in ⅛"ths.
Set of Mortise chisels ¼" to 1" in ⅛"ths.
Bevel
20 oz. claw hammer
Warrington hammer - Pane Hammer
Tack hammer
12" Pocket level
Plumb-bob
Assortment of screwdrivers
4 lb. Axe.


80 Ft.
40 Ft.
LATHE
TIMBER RACKS
GLASS CUTTING BENCH
PAINTING AREA
CIRCULAR SAW
CIRCULAR SAW
PLANER
CROSS CUT SAW
WASH BASINS
MORTISER
BAND SAW
CLOTHES LOCKERS
JOINERY BENCHES
BRICKLAYERS STORE
TOOL STORE
FOREMANS OFFICE
SHELTER'S BENCH

APPENDIX VI

APPENDIX VI

6. RIGGING SHOP

Inventory of Rigging Tackle held for General Use

ITEM	SAFE WORKING LOAD	NOS. OFF
Manual Chain Blocks	15 Tonnes	2
Manual Chain Blocks	10 Tonnes	2
Manual Chain Blocks	6 Tonnes	2
Manual Chain Blocks	5 Tonnes	2
Manual Chain Blocks	4 Tonnes	2
Manual Chain Blocks	3 Tonnes	6
Manual Chain Blocks	2 Tonnes	7
Manual Chain Blocks	1.5 Tonnes	2
Manual Chain Blocks	1 Tonne	7
Manual Chain Blocks	.5 Tonne	14
Mini Lift Hoist	.25 Tonne	1
Mini Lift Hoist	.5 Tonne	1
Monkey Winch and Equipment	5 Tonnes	1
"Tirfor" Winch	1.5 Tonnes	1
Scissors Girder Clip	1.5 Tonnes	4
Scissors Girder Clip	2 Tonnes	12
Scissors Girder Clip	3 Tonnes	2
Scissors Girder Clip	4 Tonnes	2
"Felco" Girder Clip	2 Tonnes	8
"Felco" Girder Clip	5 Tonnes	1
"Yale" Pullifts	1.5 Tonnes	2
"Yale" Pullifts	3 Tonnes	1
	SIZE	
Plate Lifting Clamps	1 Tonne for up to 16 mm Plate	1
Plate Lifting Clamps	.75 Tonne for up to 16 mm Plate	1
Runway Trolley	1 Tonne to fit 76 mm to 102 mm joists	1
Runway Trolley	.5 Tonne to fit 178 mm joists only	1
Runway Trolley Scissors	.5 Tonne to fit 76 mm to 178 mm joists	1

RIGGING SHOP

Inventory of Rigging Tackle held for General Use (Cont'd)

ITEM	SAFE WORKING LOAD	SIZE	NOS. OFF
Eye Bolts	2.2 Tonnes	25 mm Shank	3
Eye Bolts	1.6 Tonnes	22 mm Shank	1
Ring Bolts	1.5 Tonnes	32 mm Shank	5
Ring Bolts	1 Tonne	22 mm Shank	4
Ring Bolts		16 mm Shank	2
Chain Slings			
Chain Sling	4.2 Tonnes	2 Leg Duplex at 90°	2
Chain Sling	4.5 Tonnes	Single Chain 19 mm	4
Chain Sling	2.5 Tonnes	Three Leg	1
Chain Sling	3.1 Tonnes	Single Chain 16 mm	16
Chain Sling	2.5 Tonnes	Single Chain 14 mm	14
Chain Sling	2 Tonnes	Single Chain 13 mm	6
Chain Sling	1.5 Tonnes	Single Chain 11 mm	2
Chain Sling	1 Tonne	Single Chain 9 mm	7
Chain Sling	.5 Tonne	Single Chain 6 mm	6
Chains vary in length from 1 metre to 4 metres.			
Lifting Beams			
3 Sheave Rope Block	.75 Tonnes		3
2 Sheave Rope Block	.75 Tonnes		4
1 Sheave Rope Block	.5 Tonnes		5
Jacks			
Ladder Jacks	15 Tonnes	305 mm lift	3
Hyd. Traverse Jack	10 Tonnes	305 mm lift	1
"Hydralite" Hydraulic Jack	25 Tonnes	225 mm lift	1
"Hydralite" Hydraulic Jack	25 Tonnes	125 mm lift	1
"Hydramite" Hydraulic Jack	5 Tonnes	80 mm lift	2

RIGGING SHOP

ITEM	SAFE WORKING LOAD	SIZE	NOS. OFF
Shackles			
Bow Shackles	12 Tonnes	51 mm	10
Bow Shackles	8.5 Tonnes	47 mm	2
Bow Shackles	7.5 Tonnes	44 mm	6
Bow Shackles	6.5 Tonnes	41 mm	6
Bow Shackles	6 Tonnes	38 mm	10
Bow Shackles	2.75 Tonnes	25 mm	3
Bow Shackles	2 Tonnes	13 mm	4
"D" Shackles	8.5 Tonnes	41 mm	2
"D" Shackles	6 Tonnes	35 mm	2
"D" Shackles	5.5 Tonnes	35 mm	2
"D" Shackles	5 Tonnes	31 mm	2
"D" Shackles	4 Tonnes	25 mm	1
"D" Shackles	3 Tonnes	25 mm	1
"D" Shackles	2.25 Tonnes	19 mm	4
"D" Shackles	2 Tonnes	22 mm	1
"D" Shackles	1.25 Tonnes	25 mm	5
Wire Rope Slings			
Wire Rope Sling	2.5 Tonnes	16 mm x 2 m.	6
Wire Rope Sling	2.5 Tonnes	16 mm x 4 m.	6
Wire Rope Sling	2.5 Tonnes	16 mm x 5 m.	6
Wire Rope Sling	2.5 Tonnes	16 mm x 6 m.	6
Wire Rope Sling	2.5 Tonnes	16 mm x 7.5 m.	6
Wire Rope Sling	4 Tonnes	22 mm x 2 m.	6
Wire Rope Sling	4 Tonnes	22 mm x 4 m.	6
Wire Rope Sling	4 Tonnes	22 mm x 6 m.	6
Wire Rope Sling	4 Tonnes	22 mm x 7.5 m.	6
Braided Rope Sling	5 Tonnes	4 m.	2
Braided Rope Sling	10 Tonnes	5 m.	4
Wire Rope Sling	For RA Autos		12
Wire Rope Sling	For 4D Autos		4
Felco Self Adjusting Sling	1.5 Tonnes		1

A [illegible] VI

RIGGING [illegible]

Scaffolding

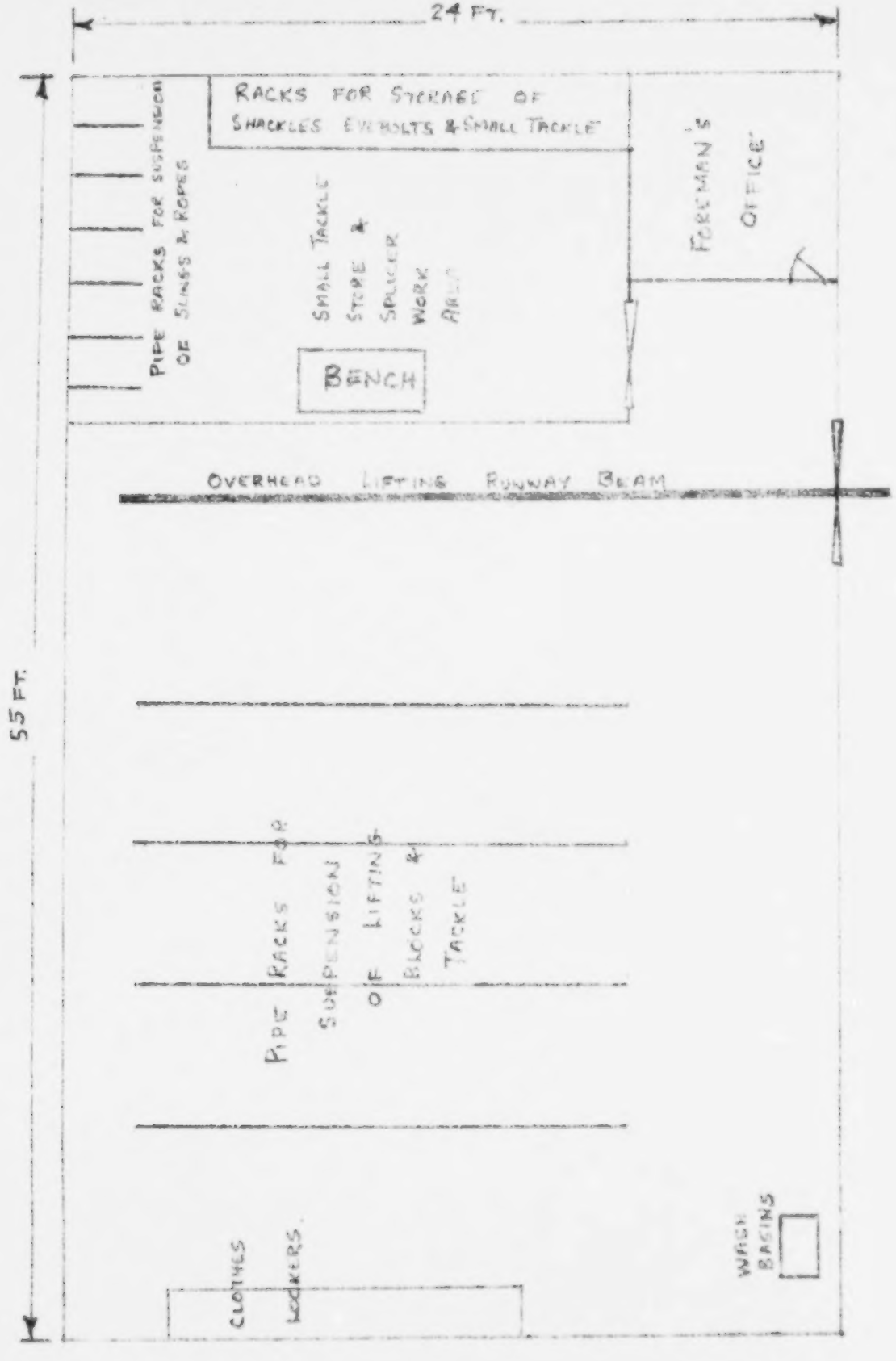
"Zip Up" quick erect scaffolding - 5 Stairway sections 2 sets of handrails
Fully erected to 10 m.

"Zip Up" Span Staging + handrails
Fully erected to [illegible] m.

"Mills" Trusses 1.5 m. Fully erected to 31 metres complete with Bases.

Scaffold Tubing 137 metres in various lengths

Scaffold Clips 300 of various types.


24 FT.
55 FT.
RACKS FOR STORAGE OF SHACKLES EYEBOLTS & SMALL TACKLE
PIPE RACKS FOR SUSPENSION OF SLINGS & ROPES
SMALL TACKLE STORE & SPLICER WORK AREA
BENCH
FOREMAN'S OFFICE
OVERHEAD LIFTING RUNWAY BEAM
PIPE RACKS FOR SUSPENSION OF LIFTING BLOCKS & TACKLE
CLOTHES LOCKERS
WASH BASINS

7. GARAGE WORKSHOP

Personnel

1 Foreman
4 Motor Mechanics
1 Non-Craft Man

Workshop Equipment

Grindstone - 10" Pedestal (2 stone)
Pillar Drill - up to ⅝" dia.
Tyre Removal Equipment (Hand Press) up to 40 x 8 Commercial Vehicle Tyres
Valve Refacer
Spark Plug Tester
Power Lubricating Equipment
Guillotine (Hard ⅛" plate)
Compressor (150 p.s.i. 40 c.f.m.)

Workshop Tools

Full Whit. A.F. and Metric Socket Set
3 Pneumatic Impact Wrenches ½" ¾" Medium and ½" Long Square drive and Impact Sockets
½ and ⅜ Portable Drills (Elec. - 50 v.)
Portable Sander (6" dia - 240 v.)
Gas welding Equipment
Pop Riveter
Universal Hub Pullers - Hand Hydraulic
Injector and Fuel Pump Testers
Mercer Gauges and Micrometers 1" to 6"
Clutch Reset and Alignment Mandrills
Set of Expanding Reamers ½" to 1½"
Compression Tester
Torque Wrenches 0 - 500 ft. lbs 500 - 1000 ft. lbs
Pressure Gauges 300 to 2000 p.s.i. (For Hydraulic system testing)
Stocks and Dies and Taps Whit. A.F. 5/16 to 1"
Circlip Removal Tools

GARAGE WORKSHOP

Motor Mechanic Tool Kit

A.F. Metric and Whit. Spanners Ring and Open ended up to 1" A.F.
½" Whit. and 36 mm. + B.A.
1½ lb. and ¾ lb. Ball Pein Hammers
Universal, side cutting, long nose, and circlip pliers
8", 6" and B.A., 2 and 3 Phillips Screwdrivers
Universal Frame Hacksaw
Scissors
Centre and Parallel Assorted Punches
10" and 14" Stillson Wrenches
8" Half Round and Flat Scrapers
6 Assorted Files

Universal Spares

Tyres
Spark Plugs
C/B 1T3
Bulbs
Dyno and Starter Brushes
Injectors
Fan Belts
Hoses Water and Hyd.
Ignition Coil
W. Wiper Arms and Blades
Washer Fibre Plain Copper Shakeproof
Unif. Nuts and Bolts and Nyloc Nuts 5/16" - ½"
14 x .012 cable 28 x.012 cable
Starter Cable
Boxes Assorted Elect. Terminals

Various amounts of Vehicle spares held, applicable to each individual type Vehicle

SLIDING DOORS

8. ELECTRICAL WORKSHOP

Personnel

3 Foremen
18 Electricians - daywork
1 Electrician - shiftwork (1 per shift)
1 Electrical fitter - daywork
7 Non craft men - daywork

Workshop Equipment

Mechanical saw
Pillar drill up to ½" dia
Pillar drill up to 1" dia
Pedestal grinder - 2 stone
Bar and angle hand bender (2 x 2 angle)
4 - Battery chargers 250 volt input 6 or 12 volt output
20 amp hours capacity
Test Bench - fitted with power supplies from full range of socket outlets over range of voltages in factory use.
Also fuel gas supply. Motor test bench - fitted with range of starters in current factory use.
1 ton lifting runway fitted with trolley and hand chain block - serving motor test area and through shop doorway.
Drying oven - 4 ft. x 4 ft. x 4 ft. - Maximum temperature 150°C
7 Monitored earth control boxes
5 Monitored earth extension leads
9 50 V: 25V. transformers
4 1,000 volt "Megger" insulation and continuity tester
6 5000 volt "Megger" insulation and continuity tester
2 "Avo" multitester wide range model
1 "Avo" minor tester
4 "Danwa" meters (voltage resistance etc.)
3 "Ferranti" 'clip-on' ammeters
Earth loop impedance tester
'Clip-on' watt meter

APPENDIX VI

APPENDIX VI.

ELECTRICAL WORKSHOP

Workshop Tools

4 Vibro Drills
2 Hammer Drills
1 "Rapid" masonry drill
1 "Lesto" Jig Saw
1 Mineral Insulated Callender Cable stripper
1 ⅜""Desoutter" Pistol Drill 50 volt
1 ½""Desoutter" Pistol Drill 250 volt
2 ¼" "Desoutter" Pistol Drill 250 volt
1 ¼" "Desoutter" Pistol Drill 50 volt
1 ¼" "Wolf" Pistol Drill 50 volt
1 ¼" "Black & Decker" Pistol Drill (Battery Power)
1 "Secomak" Hot Air Blower
2 "Sturtevant" Cold Air Blower
"Pickstone" instant heat soldering iron 250 volts.
"Henly" soldering iron 250 volts.
2 "Henly" soldering iron 50 volts
Large, Medium and Small "Pickavant" hydraulic bearing extractor
"Pickavant" bearing inserting kit
Double burner for lead and pitch melting
3 Assorted gas blow torches
2 "Hilti" cartridge gun
A set of bronze spark resisting tools for use in flame-proof areas
1 "Erma" hydraulic crimping tool with a range of dies to suit various cables

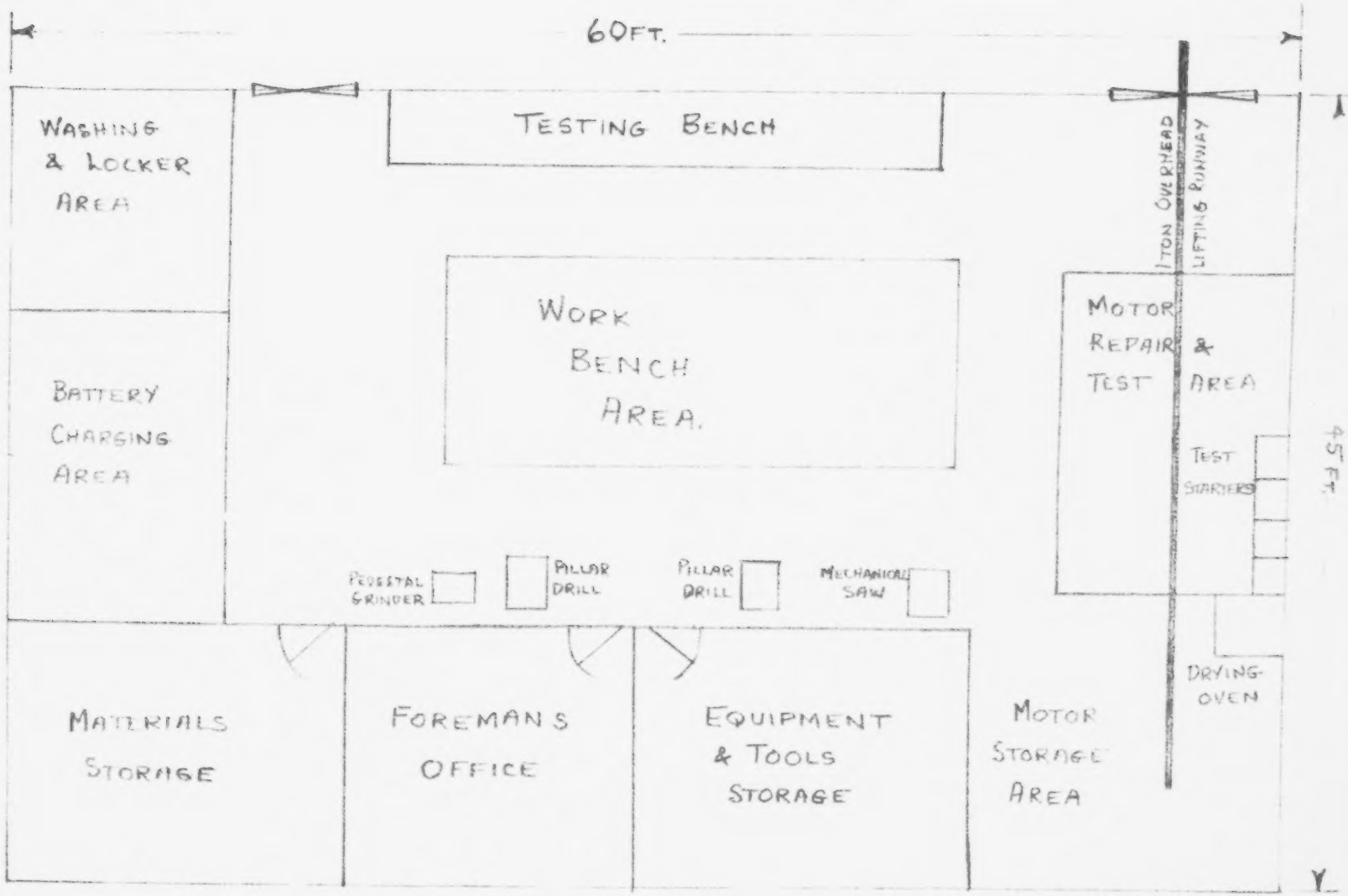
Electricians Tool Kit

Set Whitworth Spanners open end
Set Metric Spanners open end
Set Metric and 1 set Whit. Allen Keys
Set Whit. Box Spanners
Pair Side Cutters
Pair Insulated Pliers
Pair Long Nose Pliers

ELECTRICAL WORKSHOP

Electricians Tool Kit (Cont'd)

Small, Medium and Large Screwdrivers
Small, Medium and Large Star Screwdrivers (Philips head)
Stillson Wrench 10"
Test Lamp (Neon Indicator model)
1.5 lb. Ball and Pien Hammer
Knife
Cable Stripping Tool
Set B.A. Box Spanners
Set B.A. Open end Spanners
Centre Punch
Chisel
Copper Drift
Tape Measure
Kit Pyrotenax Accessories
Set A.F. Spanners open end
12" Hacksaw
Junior Hacksaw


60FT.
45FT.
WASHING & LOCKER AREA
BATTERY CHARGING AREA
TESTING BENCH
WORK BENCH AREA.
PEDESTAL GRINDER
PILLAR DRILL
PILLAR DRILL
MECHANICAL SAW
MOTOR REPAIR & TEST AREA
TEST STARTERS
OVERHEAD LIFTING GANTRY
DRYING OVEN
MATERIALS STORAGE
FOREMANS OFFICE
EQUIPMENT & TOOLS STORAGE
MOTOR STORAGE AREA

INSTRUMENT WORKSHOP

Personnel

3 Foremen
17 Instrument Mechanics - daywork
1 Instrument Mechanic - shiftwork (1 per shift)
2 Non-craft men

Workshop Equipment

Instrument lathe - 6" swing over bed 2' 6" long
Pillar drill - up to ½" dia.
Pedestal grindstone - 2 stone
Engraving machine - for production of nameplates
Millivolt potentiometer
Radio Frequency equipment - Beat Frequency Oscillators and R.F. signal generator, digital counter with range to 999,000 cps for "Multitone"personal paging equipment
"Wallace and Tiernan" pneumatic test sets with 30 psig supply for instrument output testing with input signal range of up to 24 psig in steps of .01 psi.
"Avometers" - 20,000 ohms/volt - resistance voltage tester
Bench Oscilloscope - waveform measurement
Standard pressure gauges
Dead weight tester for guages
Heated sand bath - for temperature indicator testing
Manometers (Mercury and water)
Stopwatch
Pistol drills and monitored earths ¼" and ½" dia 240 Volt
Battery drill 5/16" dia.
"Megger" - continuity tester
pH test units

Instrument Mechanic Tool Kit

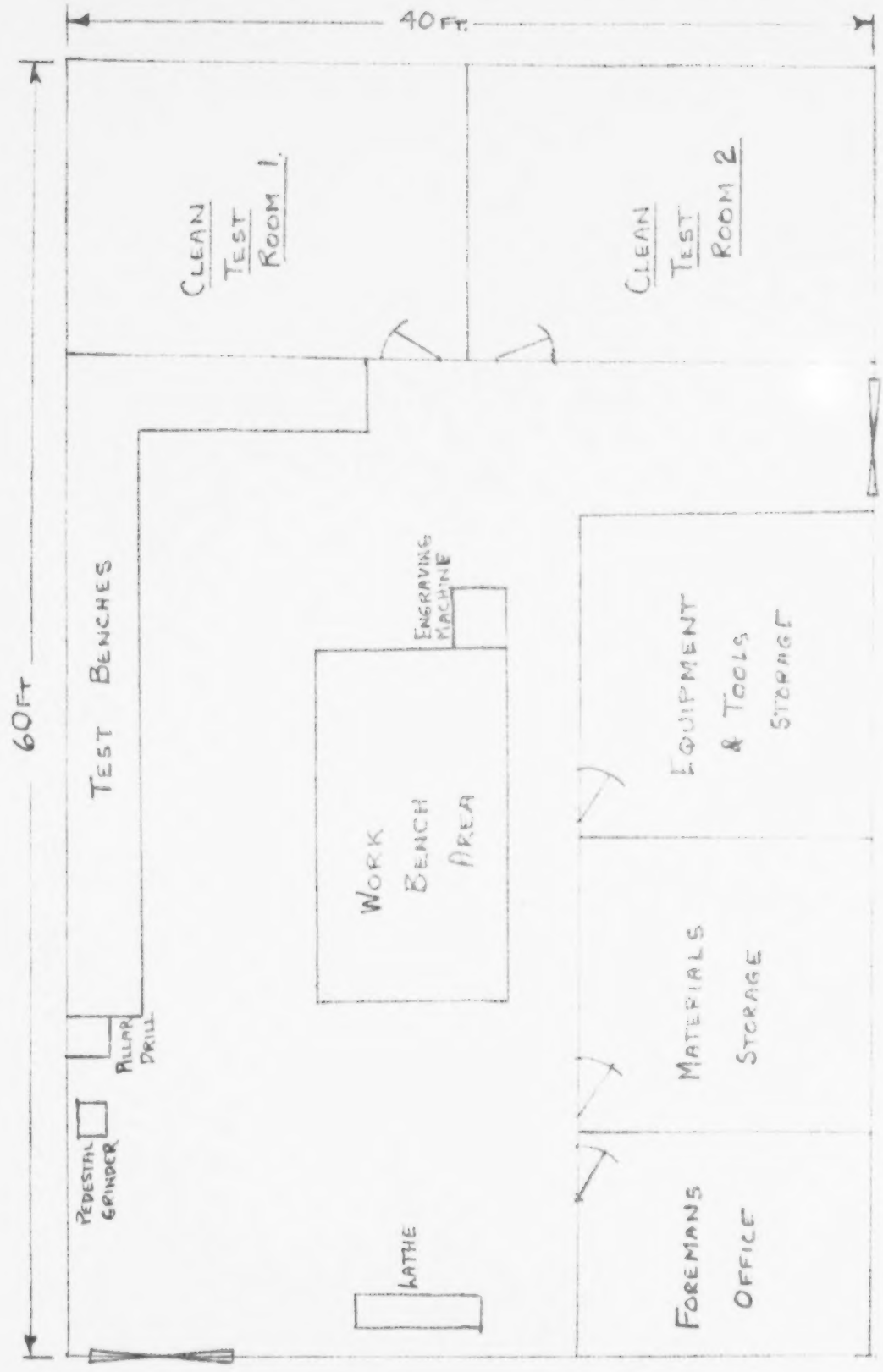
1½ lb. Ball pein hammer
½ lb. Ball pein hammer
Set of Whitworth open jaw spanners
Set of A.F. open jaw spanners
Set of B.A. open jaw spanners
Set of metric open jaw spanners

APPENDIX VI.

INSTRUMENT WORKSHOP

Instrument Mechanic Tool Kit (Cont'd)

Pair of 5" Dividers
Pair of 5" inside calipers
Pair of 5" outside calipers
Small screwdriver
3", 6" and 8" screwdriver
Phillips head screwdriver
12" Hacksaw
Junior hacksaw
Tweezers
Watchmakers screwdriver
Watchmakers eyeglass
Gauge pointer extractor
Set of Allen keys
10" and 14" Stillson wrenches
Penknife
Set of Needle files
Assortment of large files
Insulated pliers
Centre punch
Set of pin vices
Pyrotenax Stripping and crimping tools
5" side cutters
Long nose pliers
Pencil brush.


40 Ft.
60Ft
CLEAN TEST ROOM 1.
CLEAN TEST ROOM 2
TEST BENCHES
ENGRAVING MACHINE
WORK BENCH AREA
EQUIPMENT & TOOLS STORAGE
MATERIALS STORAGE
FOREMANS OFFICE
PILLAR DRILL
PEDESTAL GRINDER
LATHE

MAINTENANCE WORK REQUEST SYSTEM

I. PURPOSE

To define the correct methods to be used for requesting work from Maintenance Department and to define the responsibilities of the various Works Personnel involved.

II. POLICY

It is the aim of Works Management that all requests for Maintenance effort shall be recorded in writing either by entry in the Area Maintenance Log Sheet system or through the Work Order System.

This will ensure that:-

1. Clear instructions are received by the execution group.

2. That the work is correctly reported against cost classifications.

3. That information is provided and recorded of all work carried out by Maintenance Department. This information, together with Cost Records, will provide staff with historical information for improvement investigations and recapping purposes.

4. That an equitable system of priorities is operated.

5. That the workload of Central Trades and Centralised Maintenance Group can be planned and scheduled.

III. PROCEDURE

All work will fall within two systems:-

(a) The Area Log Sheet System

Work can be requested verbally or in writing directly to the Area Maintenance Foreman or Supervisor. For control and information purposes requests executed by Area workshop Labour will be entered on Section Log Sheets by the Maintenance Foreman responsible. The Log Number will be used for all time-booking and material requisitioning purposes.

(b) The Work Order System

A Work Order is required for:-

i) All work to be carried out by the Centralised Maintenance Group and Instrument/Electrical Group. Minor assistance work of less than two man hours can be requested verbally.

ii) All installation, replacement installation and major repair work for which senior management authorisation has been received. These will be given a Job Number.

Work Orders will be issued by the Work Order Clerk in Central Planning Group. Emergency work may be started without a Work Order but it will be the responsibility of the appropriate Maintenance Supervision to obtain the necessary Work Order at the earliest opportunity.

(c) Allocation of Priorities

i) Priorities will be allocated by the Work Order Clerk on the recommendation of the Originator.

ii) There will be three priority ratings:-

Priority 1

A job which requires immediate attention and on which Overtime should be worked if necessary for completion. These would be jobs

(a) To avoid serious hazard to personnel or plant.

(b) To prevent plant shutdown or minimise downtime to avoid serious production loss.

Priority 2

Work which does not require an immediate start (i.e. more than 20 hours notice) but which has a critical completion time requirement.

Priority 3

All other work which will be completed to an agreed date, or on a scheduled basis.

iii) Safety jobs dealing with an immediate hazard should normally be given Priority 1 and other safety jobs will be given favourable priority in drawing up Priority 2 schedules. Such Work Orders must be endorsed 'Safety'.

iv) In the event of disagreement regarding priorities the decision of higher levels of Management up to Works Manager will be sought.

v) To ensure effective planning, Priority 1 should be avoided. The use of this priority will be investigated by Maintenance Improvement Group and reported regularly.

(d) Distribution of work orders

i) Work Order Forms will be printed on sensitised paper with pre-printed serial numbers with prefix letter 'W' to distinguish work order numbers from job numbers which will bear the prefix letter 'J'.

ii) Three copies will be issued as follows:-

Copy No. 1 - To the Planner/Foreman/Craftsman

On completion of the job this copy will be passed to the appropriate Central Files, in the case of Centralised Maintenance Group jobs via the Planner, in the case of Construction jobs via the Project Progress Planning section.

Copy No. 2 - To be retained in Planning Group for information and plant record purposes.

Copy No. 3 - To the appropriate General Superintendent when improvement or work to assist production.

To the appropriate Maintenance Superintendent or Engineer when true repair work. This copy will then be forwarded to the Originator.

(e) Labour and Material Costs

Engineering labour, Supply stores and Machinery stores transactions will be charged to the appropriate Work Order Number, Job Number, Log Number or Department/Section Classification.

IV. RESPONSIBILITIES

A. Originator

1. When a Work Order is requested adequate details should be given to the Work Order Clerk. If necessary, there should be prior consultation with Engineering Supervision.

2. Where appropriate, sketches or written requests may be sent by internal mail to Planning Group.

3. The priority rating must be recommended.

4. A Cost Classification must be agreed with the Work Order Clerk.

5. Maximum notice of requirements should be given.

B. Central Work Order Clerk or Engineering Supervision issuing Work Orders.

1. Work Orders must be written legibly, clearly and promptly.

2. There must be a brief descriptive title.

3. The appropriate distribution and date of issue must be recorded.

4. A suitable priority rating must be quoted.

5. A Cost Classification must be allocated.

6. Where necessary, work requirements will be referred to Services Engineers, or the Maintenance Improvement Group for investigation.

C. Engineering Supervision

1. Production Department will initiate Work Orders for Maintenance work to be executed by Centralised Maintenance Group after discussion with Area Maintenance of the work required.

2. Work Orders will also be initiated by other departments for work to be carried out by Central Trade and Centralised Maintenance Group or by Construction Group.

3. Work Orders received will be executed strictly in accordance with instructions.

4. Amended instructions will be obtained if the job appears impracticable, inefficient or undesirable.

5. For construction work, Trade assistance will be obtained by issue of a Work Order.

MAINTENANCE AND REPAIR COSTING

Engineering Cost Classifications

I. PURPOSE

The purpose of this procedure is to provide a guide to the correct classification of engineering expenditure and to define the responsibilities of those concerned.

II. POLICY

1. Capital expenditure will be segregated from revenue expenditure for Taxation purposes.

2. The responsibility for capital expenditure will be properly allocated to maintenance or operating departments.

3. The responsibility for various types of maintenance expenditure will be properly allocated to maintenance or operating departments.

4. Repair expenditure will be sub-divided for control purposes.

III. PROCEDURE

A. Capital Expenditure

1. Definition

It is necessary for taxation purposes, that certain types of expenditure are classified as capital additions to our plants and are not paid for out of revenue.

Any expenditure which increases the value of our plant is, strictly speaking, a capital addition but it is not always easy in practice to distinguish between Capital and Revenue expenditure. The final authority on such matters rests with the Inland Revenue Department but our Accounting Department will provide guidance.

2. Sub-Classification of Capital Expenditure

For management purposes, Capital Expenditure will be further sub-divided as follows:

(a) Maintenance Capital

Any capital expenditure designed to reduce true repair costs, prolong the life of equipment or increase its mechanical availability.

(b) Earnings Capital

Any capital expenditure justified on the basis of additional earnings or reduction of operating costs.

(c) Plant Improvement Capital

Any capital expenditure not covered above, i.e. which is designed to improve plant safety, appearance or convenience without any additional earnings.

NOTE: A capital job may be distributed on a percentage basis over these three classifications.

3. Mechanical Expense

All maintenance expenditure chargeable to revenue will be known as the 'Total Mechanical Expense'. It will be sub-divided as follows:

(a) True Repairs

Normal repairs to increase mechanical availability or prolong the life of equipment. It will include planned maintenance inspections, statutory inspections and all painting costs not classified as capital expenditure.

(b) Plant Improvement

Work carried out by Maintenance Department, chargeable to revenue, but designed to improve the safety, appearance or operating convenience of the plant.

(c) Work to assist

Work carried out by Maintenance Department to assist operating departments in maintaining process availability, e.g. cleaning blocked lines or heat exchangers, cleaning extruders, etc.

NOTE: All maintenance jobs will be allocated to one class - whichever is predominant.

4. Dismantling Expense

This covers the expenditure associated with the removal of capital equipment from the plant and will always be covered by a dismantling job number.

It will be included in the appropriate section of Mechanical Expense according to the nature of the associated capital job. If not associated with an installation, it will be classified as plant improvement.

5. Start-Up Expense

This covers the expenditure associated with the start-up and commissioning of new plant and will always be covered by an engineering job number. It will be costed as a direct expense on the product cost sheet.

APPENDIX VIII

[illegible]

[illegible]

I. [illegible]

To outline the methods to be employed for accumulating engineering costs under the various classifications and to define the responsibilities of the Works personnel involved.

II. POLICY

It is the intention of Management to promote the proper control and review of engineering expenditure by providing a detailed breakdown of engineering costs.

Such costs must, in the first instance, be divided between capital and revenue expenditure and be allocated to the various product cost centres for normal financial costing.

In addition, these costs will be further sub-divided to assist in their effective control.

This information will be summarised and issued monthly by Accounts Dept. in the manner outlined below. It is important that all employees understand the need for accuracy and consistency in following these procedures.

III. [illegible]

(a) Engineering Cost Summary

For costing purposes the Works is divided into operating sections of the various departments. A list of these cost sections is provided by Accounts Dept., who will notify revisions as they are necessary. A Mechanical Expense Report is issued monthly by the Accounts Dept. for each of these sections.

The total True Repair cost is sub-divided into four classifications:

Dept. No./Section/10 - All General Repairs
Dept. No./Section/11 - All Instrument Repair Work
Dept. No./Section/12 - All painting work
Dept. No./Section/14 - All electrical repair work.

Further cost classifications utilising equipment sub groups may be added as appropriate.

The other types of mechanical expense have been allocated the following cost numbers.

Plant Improvement	Dept. No./Section/91
Work to Assist	Dept. No./Section/92
Earnings Expense	Dept. No./Section/93

The approximate time allocation must be recorded for each maintenance employee each day on his Daily Job Card. The hours worked will be allocated to the Log Number, Work Order Number, Job Number or to the appropriate cost classification as outlined below.

More than one job card per employee may be required.

(C) Materials Cost Allocation

Materials drawn from Machinery or Supply Stores account will be charged to the Job Number, Work Order Number, Log Number and Dept./Section/Classification as appropriate.

(D) Contract Charges or Outside Supplies

Contract services or equipment purchased from outside suppliers will be charged to a Job Number, Work Order Number, Log Number or cost classification number as appropriate.

IV. RESPONSIBILITIES

A Daily Job Card, coloured according to his trade, must be issued to each employee at work and returned to Accounts Department the following morning.

Job cards covering week-end work will be submitted on Monday morning.

1. All Maintenance Supervision

a) All time will be allocated to the nearest half-hour and will be covered by the following reference numbers, entered in the appropriate column of the Daily Job Card:-

i) A Serial Number

This will either be a Work Order Number or a Log Number

and a

ii) Charge Number

This will either be a Job Number or a Dept./Section/ Classification number.

b) All work carried out by shift men outside normal working hours will be entered on a Weekly Time Sheet instead of daily job cards, and be charged to "Shift Maintenance".

c) All work carried out on a Job Number for construction work - Charge to Job Number or Project Number only.

Sample Job Descriptions for:

1. General Superintendent of Maintenance
2. Superintendent of Area Maintenance
3. Maintenance Improvement Staff Engineer
4. Maintenance Planning Engineer
5. Area Maintenance Foreman
6. Maintenance Planner

POSITION DESCRIPTION

TITLE

GENERAL SUPERINTENDENT OF MAINTENANCE

DEPARTMENT

MAINTENANCE

REPORTS TO

WORKS MANAGER

Draft Approved by _____ Date _____

FUNCTION:

Provides a service to the Plant by controlling the in-works engineering and maintenance function (exclusive of process and design engineering and major new construction) to ensure the safe and timely execution of engineering work at minimum cost consistent with maximum overall operating efficiency. Assists in the development of works equipment directed towards improving its reliability or reducing its maintenance costs.

DUTIES:

1. Prepares and submits for approval plans, objectives, and budgets; reviews and progresses plans with subordinates to achieve optimum effective maintenance programmes; develops and directs the implementation of preventative maintenance and repair programmes.

2. Confers with [illegible] on plans, problems, priorities and achievements.

3. Negotiates with Trade Union Representatives on personnel problems, interpretation of procedures and introduction of new methods within the maintenance department.

4. Develops subordinates, administers salaries and training in order to achieve maximum utilisation of manpower resources and eliminate restrictive practices.

5. Controls Engineering Stores, reviews inventories, authorises new stock items, write offs, etc. to maintain inventories at reasonable levels.

6. Establishes and maintains procedures and policies to ensure the safety of personnel and that housekeeping is of a high standard.

SUPERVISION:

Direct Supervises the activities of the following personnel:-
6 senior salaried staff and through these the activities of 42 salaried and 380 hourly employees.

Functional Nil.

POSITION DESCRIPTION

TITLE

SUPERINTENDENT OF AREA MAINTENANCE

DEPARTMENT

MAINTENANCE

REPORTS TO

GENERAL SUPERINTENDENT OF MAINTENANCE

Draft Approved by _____ Date _____

FUNCTION:

Directs and controls day-to-day mechanical maintenance and emergency repairs of production plants, utilities and non-mechanical services to ensure maximum availability of equipment at minimum cost.

DUTIES:

1. Directs day-to-day mechanical maintenance of production plants, utilities and works service to keep equipment in safe and efficient condition at minimum cost.

2. Initiates repairs in cases of plant break-down and emergency to minimise loss of production.

3. Reviews stock levels of plant spares with Stores Supervisor to ensure availability of spares consistent with minimum inventory.

4. Controls the use of Company-controlled waste disposal tipping sites to prevent chemical contamination of the river or adjacent farm land.

5. Maintains good communications with other maintenance and production staff for discussion of maintenance priorities, plans problems in order to make best use of Company resources.

6. Develops and executes objectives and cost improvement programmes; prepares and reviews area maintenance administrative budgets and true repair budgets for manufacturing plants, utilities and non-mechanical services.

7. Implements Company personnel and safety policies to achieve Company objectives and promote employee welfare.

8. Assists in formulation and execution of training programmes for foremen, craftsmen and apprentices.

SUPERVISION:

Direct:	Supervisors and Foremen.	10
	Clerical	1
	Hourly	94
		105
Functional:	Nil	

POSITION DESCRIPTION

TITLE

STAFF ENGINEER

DEPARTMENT

MAINTENANCE

REPORTS TO

SUPERINTENDENT MAINTENANCE IMPROVEMENT GROUP

Draft Approved by _____ Date _____

FUNCTION:

Performs staff engineering work to reduce maintenance costs and provide technical assistance to maintenance line supervision.

DUTIES:

1. Develops maintenance cost improvement programmes for an assigned production group; analyses maintenance costs to identify areas where economies could be made.

2. Performs engineering design work to implement cost improvement projects and assigned minor capital jobs according to statutory requirements, Company standards and Codes of Practice.

3. Prepares enquiries, expenditure appropriation requests, purchasing requisitions and design packages; checks drawings and manufacturers specifications.

4. Checks installation work and assesses the effectiveness of projects in meeting objectives.

5. Provides line supervision with technical advice and information when requested.

6. Assists in the preparation and presentation of Maintenance department training programmes on specialised techniques.

7. Studies technical literature and holds discussions with manufacturers representatives to keep up-to-date with new equipment and materials.

Functional: Frequently provides direction and guidance on the carrying out of engineering work to draughtsmen, craftsmen, planners, foremen and contractors.

POSITION DESCRIPTION

TITLE

PLANNING ENGINEER

DEPARTMENT

MAINTENANCE

REPORTS TO

SUPERINTENDENT OF [illegible] WORKSHOPS & PLANNING

Draft Approved by _____ Date _____

FUNCTION:

Directs planning and scheduling of maintenance work to ensure most economical utilisation of human and material resources and minimum interference to production; develops improved planning methods.

DUTIES:

1. Supervises the day-to-day work of planning staff to ensure an acceptable standard of planning; resolves problems involving engineering considerations, priorities and emergencies.

2. Develops and controls long-term plans for major engineering work, planned maintenance, plant shutdown maintenance and insurance inspections.

3. Reviews cost of maintenance jobs to anticipate over-expenditure and requests authorisation for further expenditure when necessary.

4. Reviews work back-log and directs scheduling of work to ensure steady work load for each craft group.

5. Controls the maintenance of essential records and ensures that full use is made of them as a tool to improve maintenance efficiency.

6. Develops new techniques to improve the planning function; prepares objectives for the group and systematically works to achieve them.

7. Maintains good communications and promotes good relations with

9. Implement Company personnel, safety and housekeeping policies to achieve Company objectives and promote employee welfare.

10. Develop training programmes for planning staff.

QUALIFICATIONS:

Diploma: Professional/Qualificative 7
Diploma 2
9

Additional: Nil

POSITION DESCRIPTION

TITLE

AREA MAINTENANCE FOREMAN

DEPARTMENT

MAINTENANCE

REPORTS TO

AREA MAINTENANCE SUPERVISOR

Draft Approved by _____ Date _____

FUNCTION:

Supervises craftsmen carrying out day-to-day maintenance and emergency repairs of production plants; ensures good engineering standards, safe working methods and minimum costs.

DUTIES:

1. Plans day-to-day maintenance and minor repairs of production plants in conjunction with production staff to ensure maximum availability of equipment; arranges emergency repairs in cases of plant breakdown.

2. Allocates work to craftsmen and issues instruction on working methods and safety precautions; supervises work in progress to maintain adequate work tempo and ensure that work is performed according to instructions.

3. Raises work orders on other maintenance sections when necessary and maintains close liaison with other sections so that activities are co-ordinated for maximum efficiency; assists Planning Section in arranging and implementing planned maintenance programmes.

4. Orders special spare parts and checks regularly that stores stocks are maintained at optimum levels.

5. Arranges training of craft apprentices as specified in the Apprentice Training programme; gives on-the-job instruction to craftsmen in the use of new tools and equipment.

6. Enforces safe working methods and conducts monthly safety meetings with subordinate employees; investigates accidents and takes action to eliminate hazards; enforces good housekeeping to promote safety and efficiency.

7. Fills in job cards, log sheets, employees time cards and weekly time sheets to computation of wages and allocation of cost charges; prepares monthly maintenance reports, inspection reports and reports on safety matters.

8. Applies personnel and other Company policies to achieve Company objectives and promote employee welfare; maintains good labour relations and, whenever possible, resolves problems directly with employees and trade union representatives.

SUPERVISION:

Direct: Hourly employees. 16-17

Functional: Nil.

POSITION DESCRIPTION

TITLE

MAINTENANCE PLANNER

DEPARTMENT

MAINTENANCE

REPORTS TO

PLANNING ENGINEER

Draft Approved by _____ Date _____

FUNCTION:

Investigates engineering work requests and prepares detailed work instructions for the execution of maintenance work with most economical use of human and material resources and minimum interference to production.

DUTIES:

1. Investigates engineering work requests as necessary to determine the exact job content, feasibility, priority and plant availability in order to collect all information needed for planning the work execution.

2. Prepares detailed instructions and cost estimates for engineering jobs, specifying the work to be performed, requirements of manpower, materials and tools, to allow scheduling and execution of work at minimum cost and with minimum interference to production; checks progress of work on site and modifies instructions if necessary.

3. Plans plant shutdown maintenance programmes using Gantt charts where a number of jobs are to be performed simultaneously.

4. Requisitions equipment and materials required for planned maintenance work and progresses their delivery.

5. Plans installation of new capital equipment based on design packets prepared by T.S.D. or M.I.T.

6. Inspects equipment under repair and reports on its condition for information and record purposes.

7. Prepares standard instruction sheets for repetitive work.

8. Checks cost of jobs and collects cost data to facilitate future planning of work by cheapest methods.

SUPERVISION:

Direct Nil

Functional Nil